Ansys

Powering Innovation That Drives Human Advancement

Recent Developments in LS-DYNA
- Part II -

New features and enhancements in LS-DYNA R16

PART I → 8:45 Tobias Erhart

- Airbag methods
- Contacts
- Material models
- Misc.
- SPG/ISPG
- LS-OPT/LS-TasC
- PyDYNA

PART II

- EM
- Implicit
- ICFD + CESE
- NVH
- IGA
- Ansys Forming
- LS-Prepost

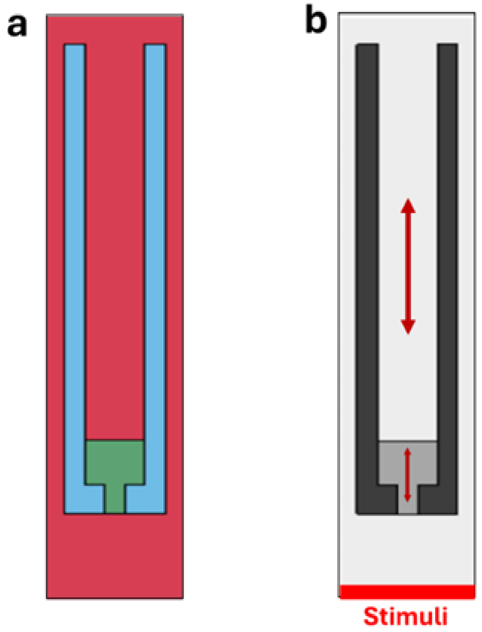
Electromagnetics

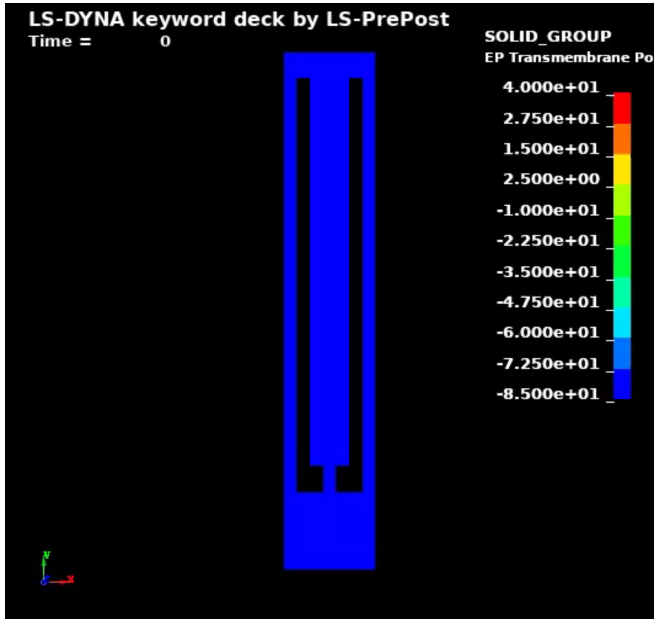
EM solver

Electrophysiology: Eikonal solver

- New eikonal solver (=get the propagation of a wave in a medium given the elemental velocities) added to mono and bi domain solvers
- Simple eikonal (only one wave in simple geometries) and more sophisticated time-stepping multifront (several waves, non-convex geometries, allows closed circuits and reentries, an important cause of arrhythmia).

  - Reentry with time stepping multifront eikonal.





Reaction Eikonal on biventricular + Purkinje network (1)

Ventricles

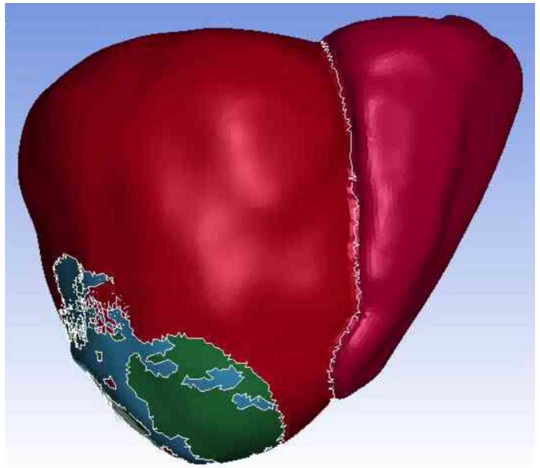
- The new development allow users to simulate the propagation of EP waves through different heart models and to study the behavior of healthy hearts versus deceased ones.
- It is a valuable tool for medical researchers and scientists.

542,623 tet elements
29,982 beams

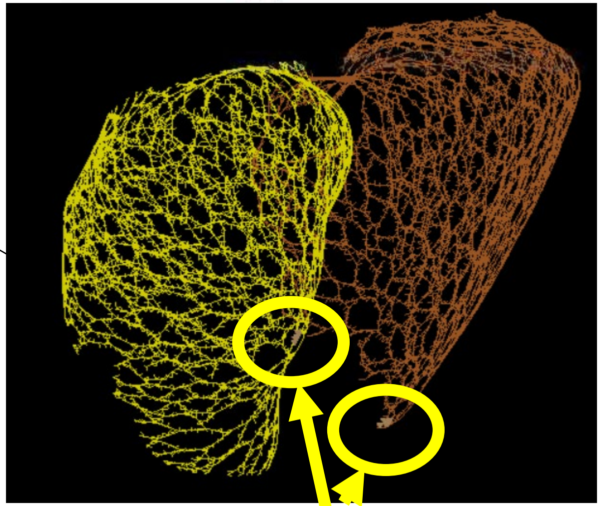
Healthy tissue

Low conductivity tissue

Scar



Purkinje network

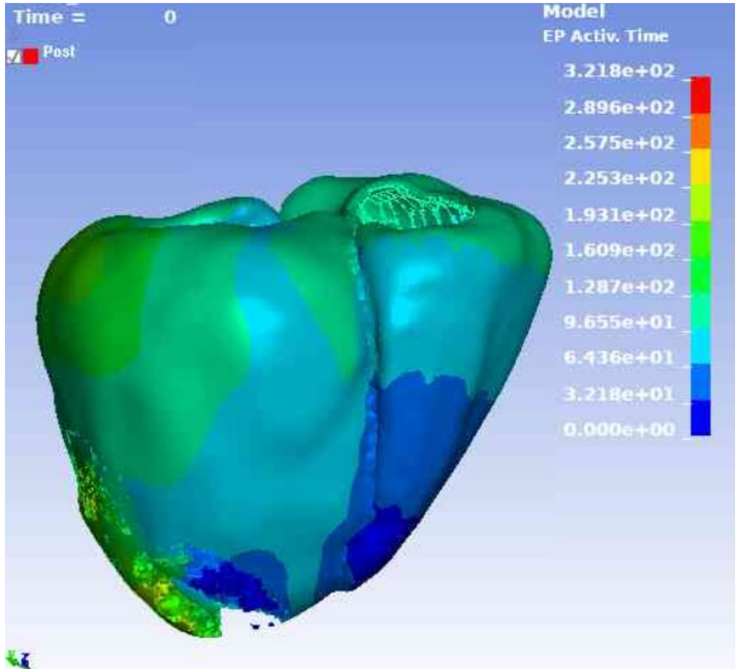


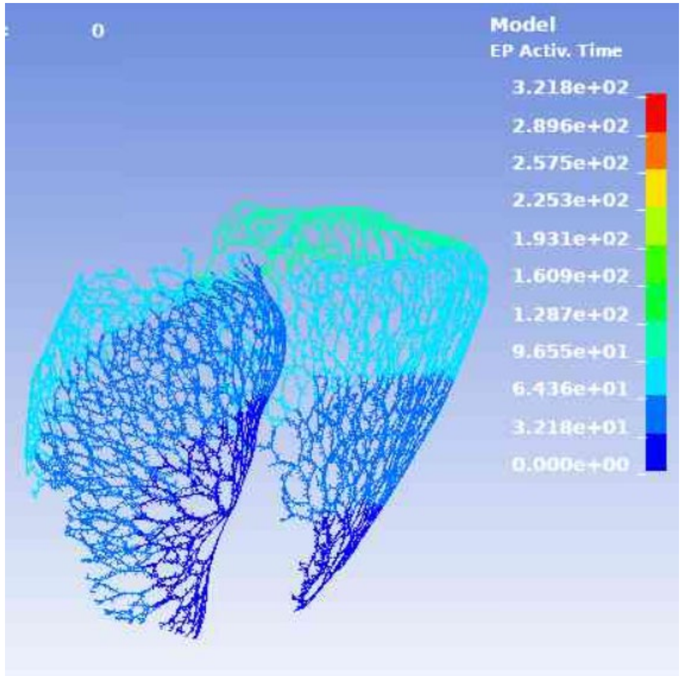
Stimuli

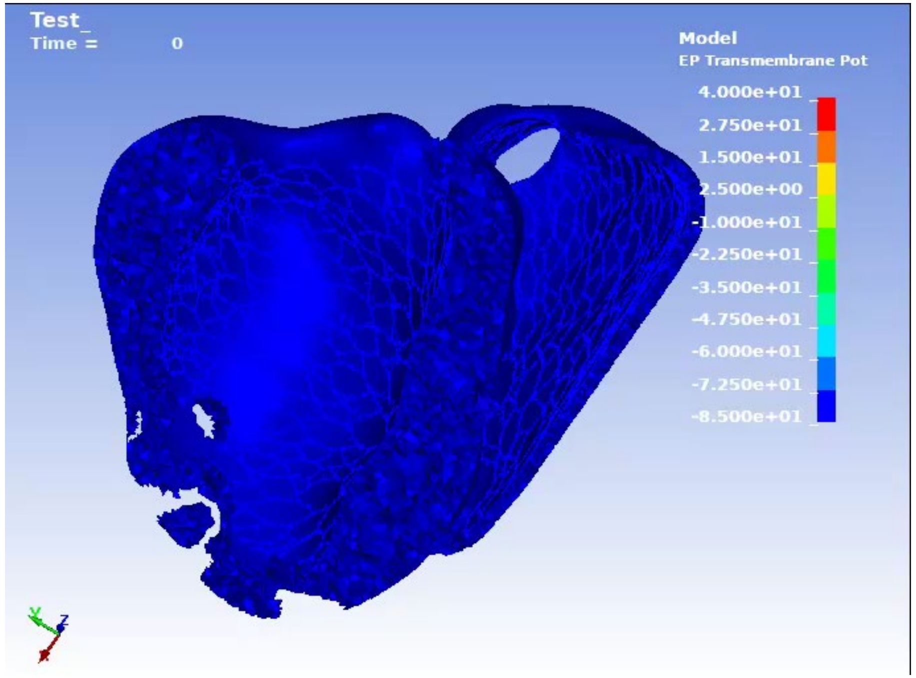
Reaction Eikonal on biventricular + Purkinje network (2)

Activation times from eikonal solver

Trans Membrane Potential







Total run took 13 minutes on 4 cpus (much faster than monodomain approach)

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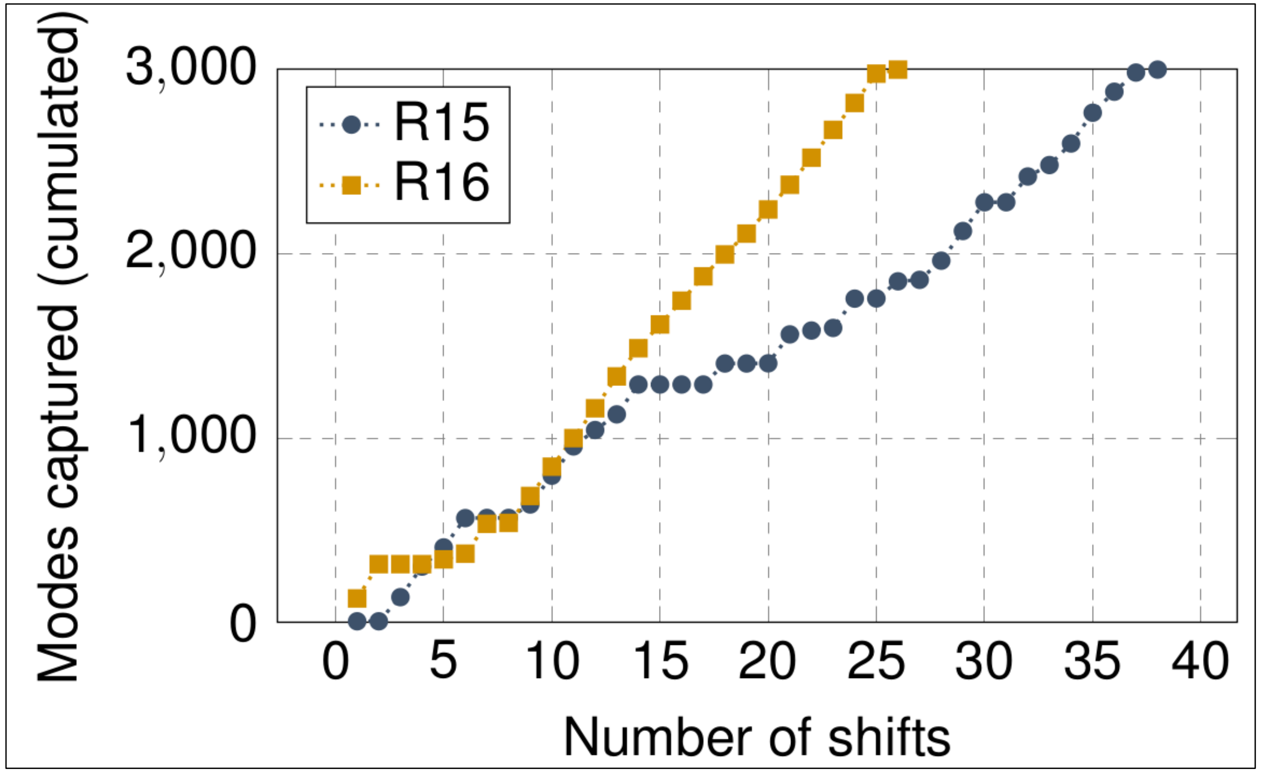
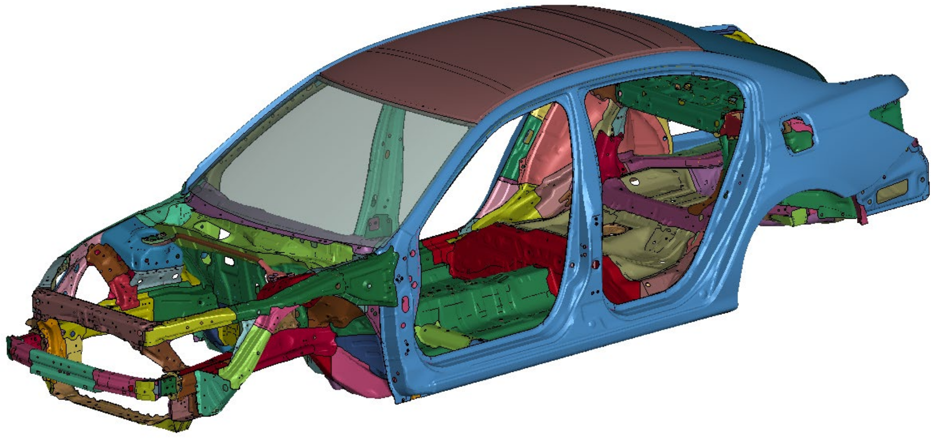
Implicit Mechanics

Implicit Mechanics – Modal analysis 1

- Lanczos flagship eigensolver: improved shifting logic. More robust and faster when computing thousands of modes.
- Example: Honda Accord model (courtesy Arup and NHTSA), 35M dofs. 3k modes:

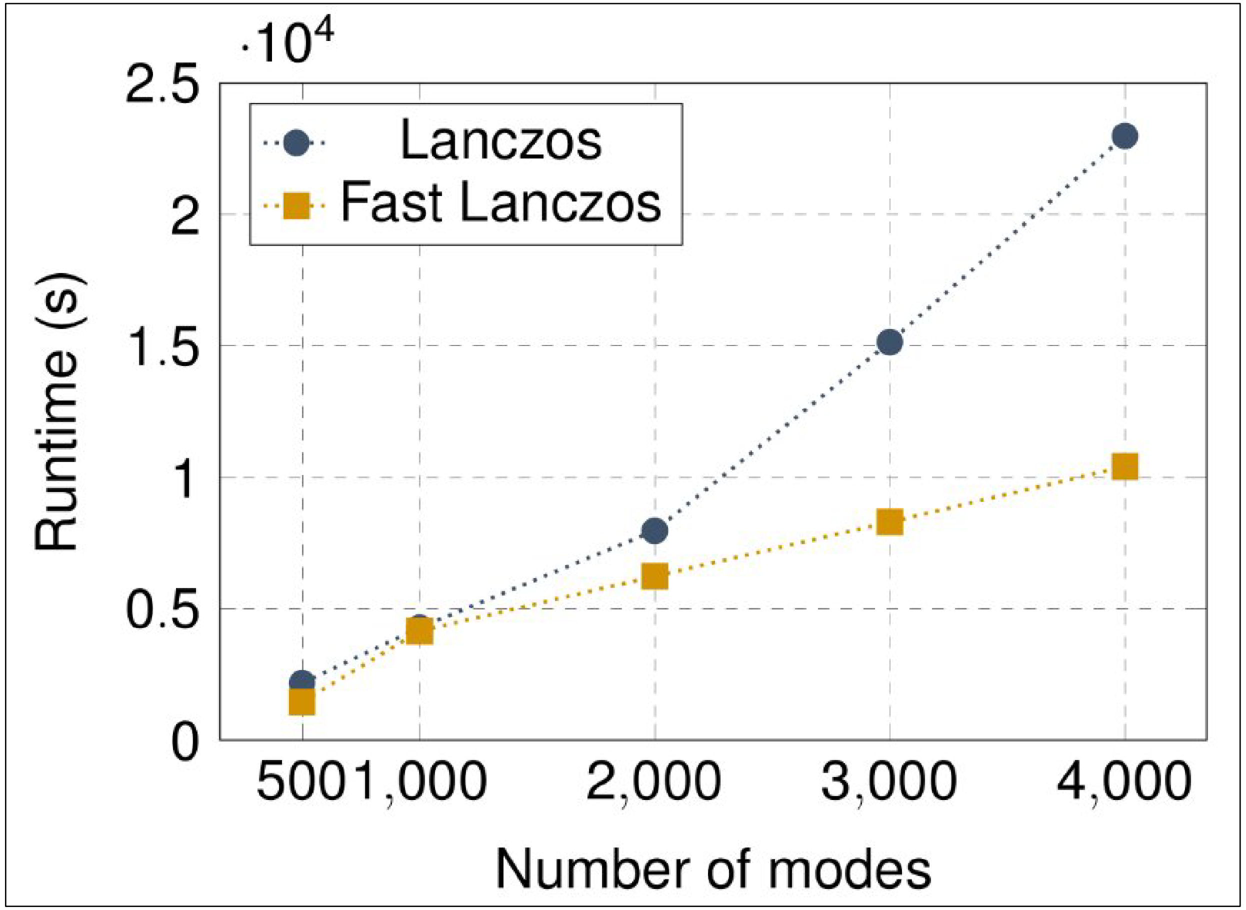




The plateaus (for R15) come from shifts that were too aggressive. R16 34% faster here.

Implicit Mechanics – Modal analysis 2

- Fast Lanczos: also improved shifting logic, and memory management.
- Example, 21.9M dof electric sedan model:



ICFD

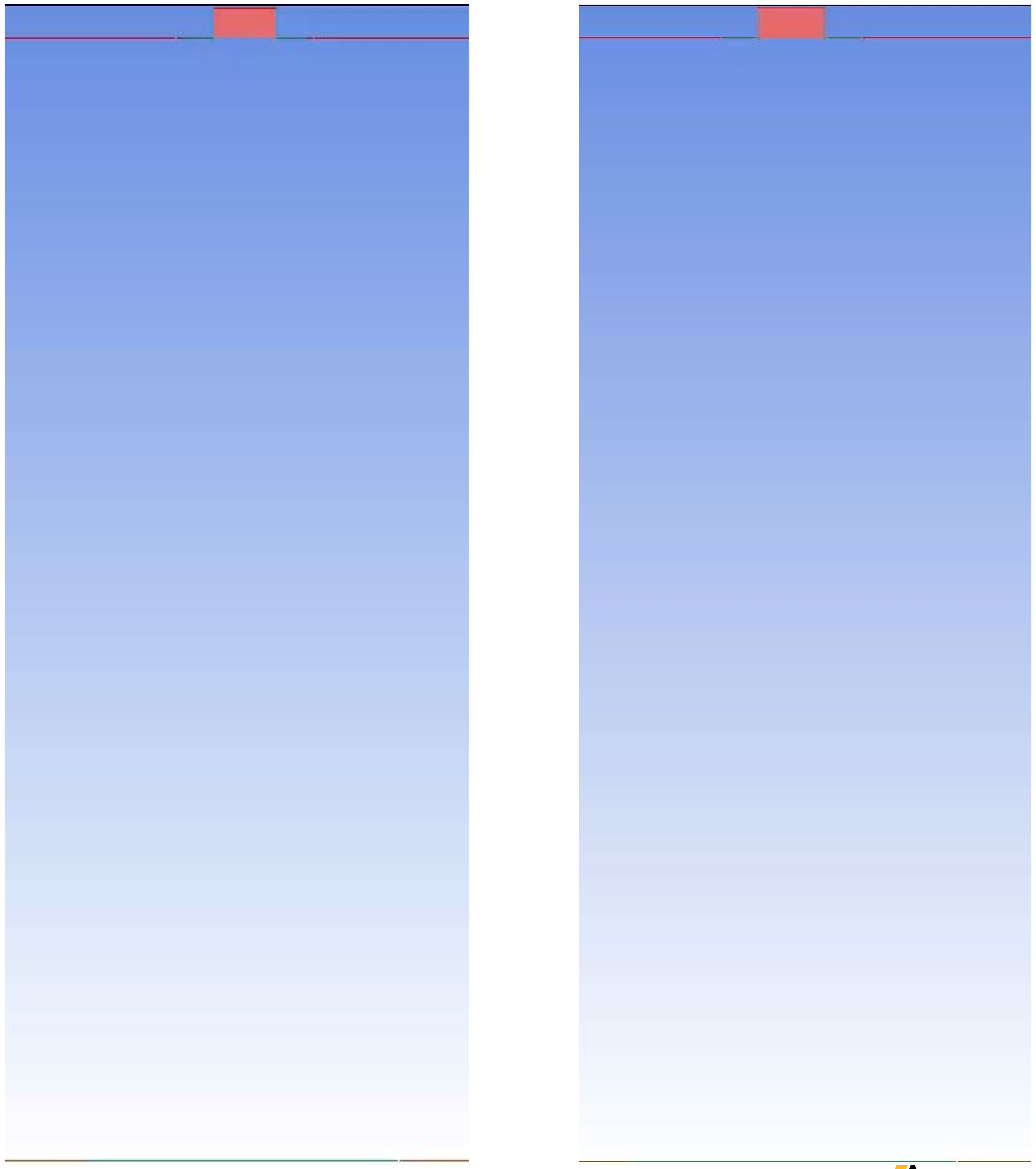
Incompressible Finite Element CFD solver

ICFD Viscoelastic flow solver

- Solve for viscoelastic tensor
- *ICFD_MODEL_VISCOELASTIC
  Oldroyd-B model

This model extends the classic Newtonian fluid equations to account for the elastic properties of certain fluids. It's particularly useful for fluids that don't behave in a purely viscous way, such as polymers, emulsions, or biological fluids.

Newtonian Oldroyd-B



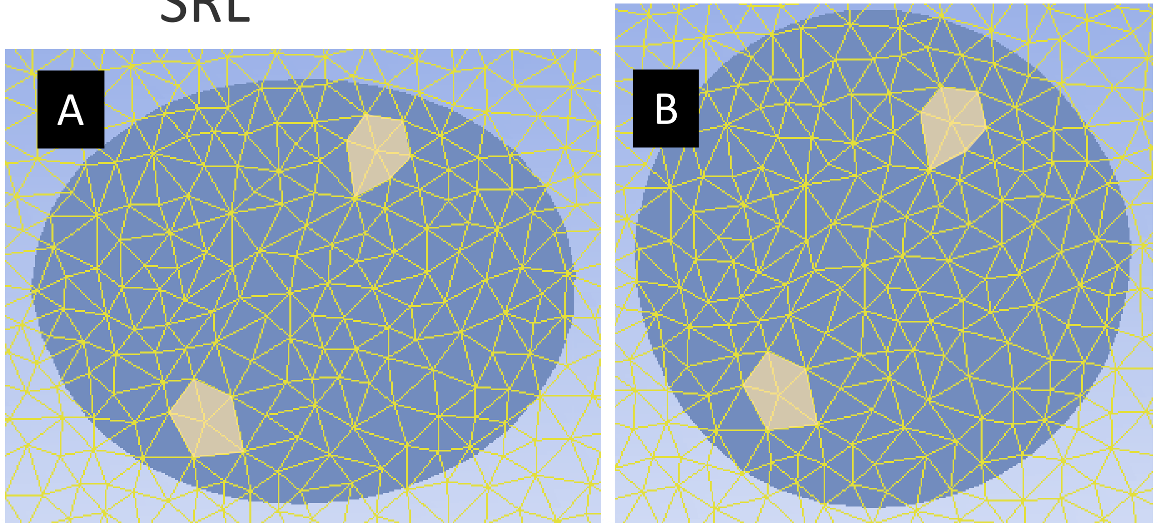
Level-set

- *ICFD_CONTROL_ADVECTION

  SLLS *(high order least squared)*

- *ICFD_CONTROL_LEVELSET

  SRL



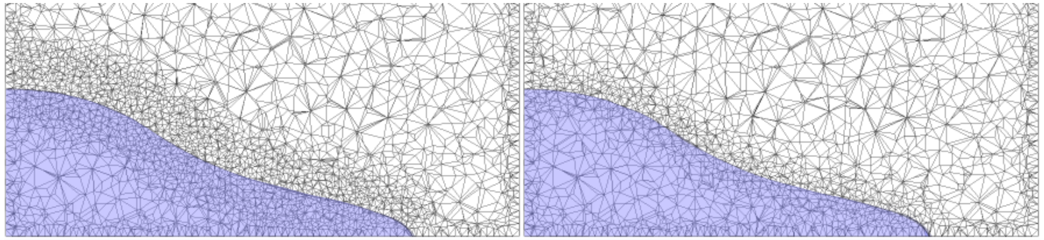
SLLS=1, SRL=1

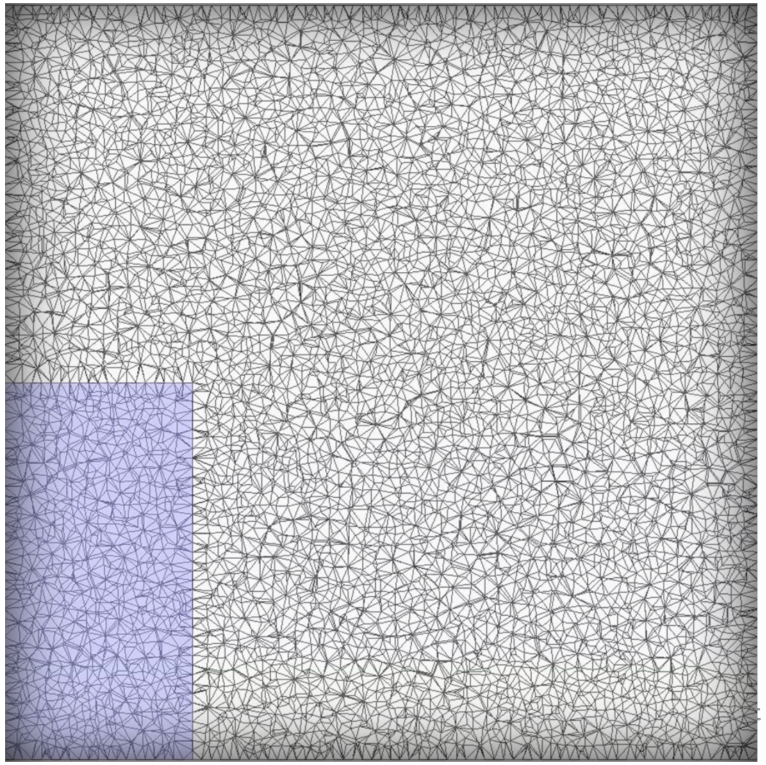
SLLS=2, SRL=2

Sphere advection:
A) low order approach
B) high order least squares approach

- *ICFD_CONTROL_ADAPT

Adaptime meshing is based only on the level set function. Elements of size MINH are placed on each side of the level set interface.





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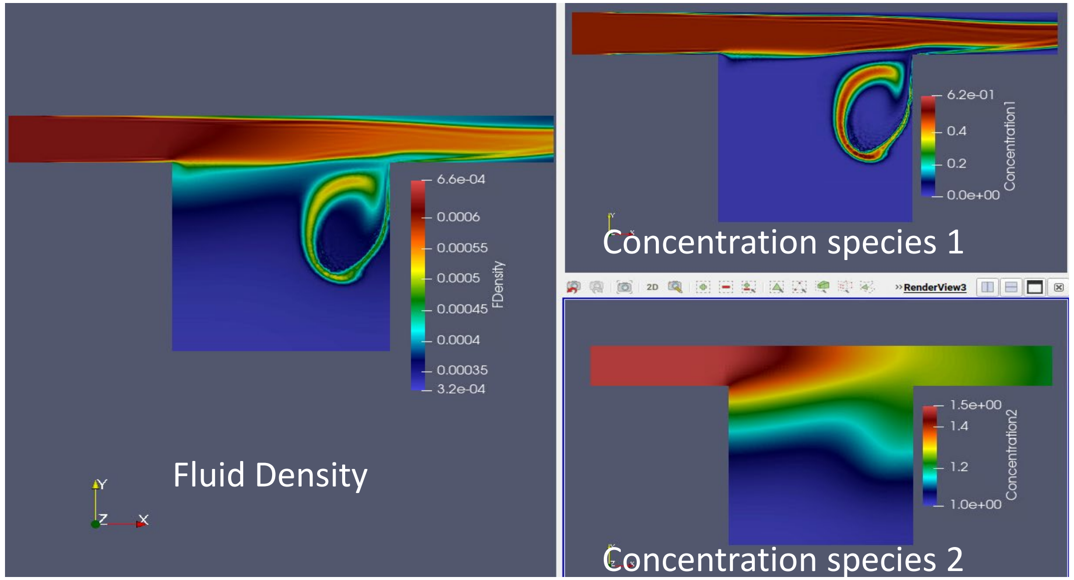
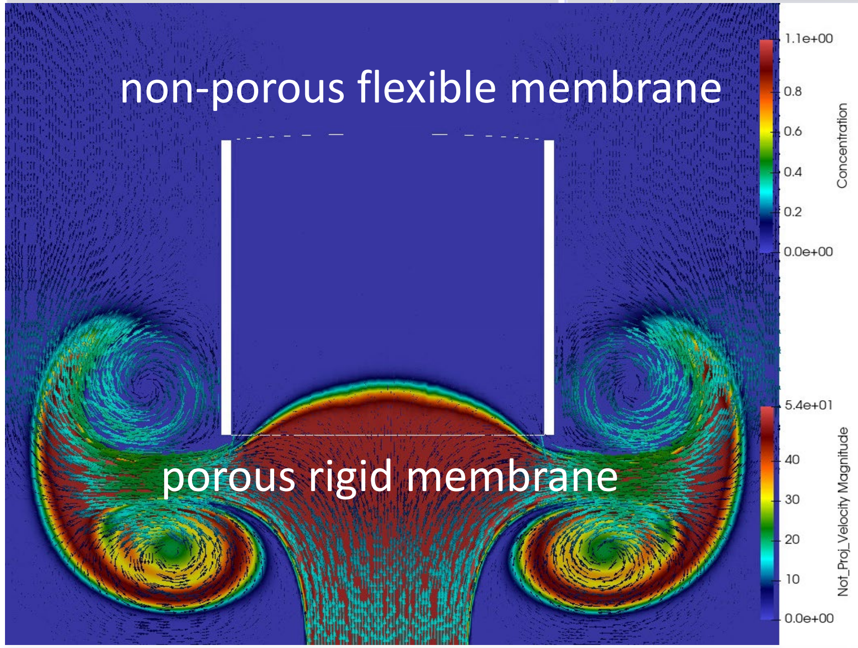
Multi-species Solver

- The fluid density can be treated as a general non-linear function of the species concentrations.

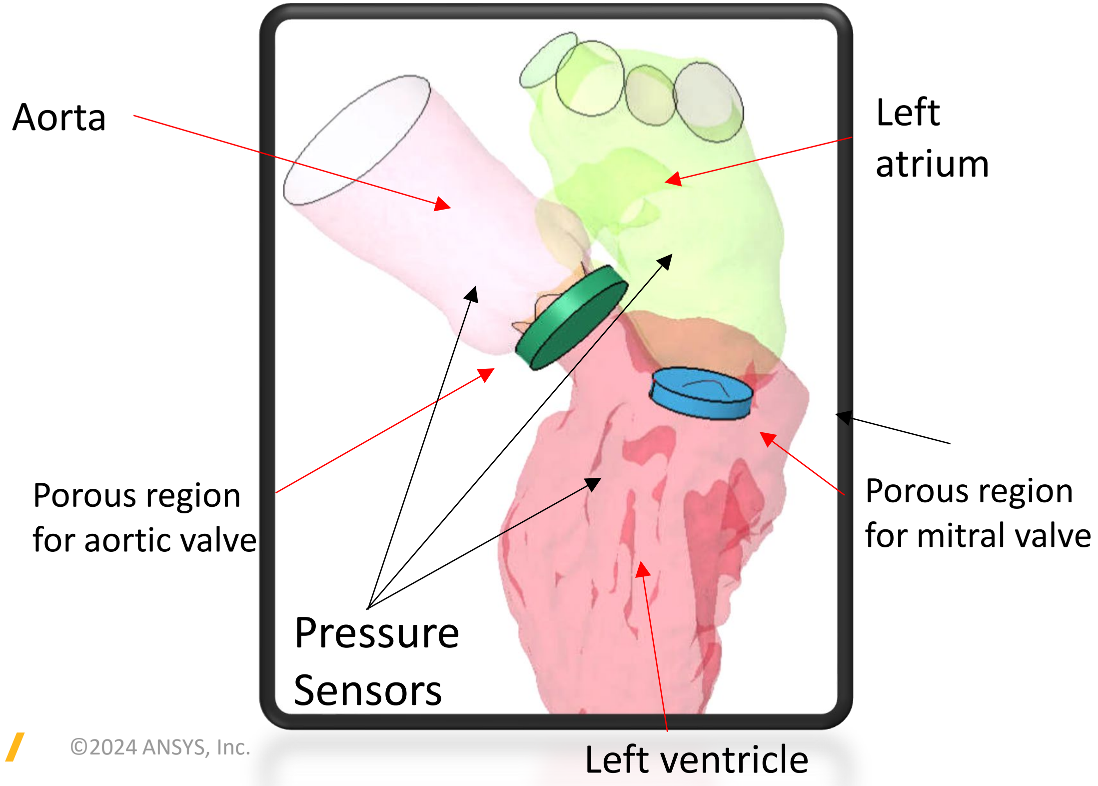


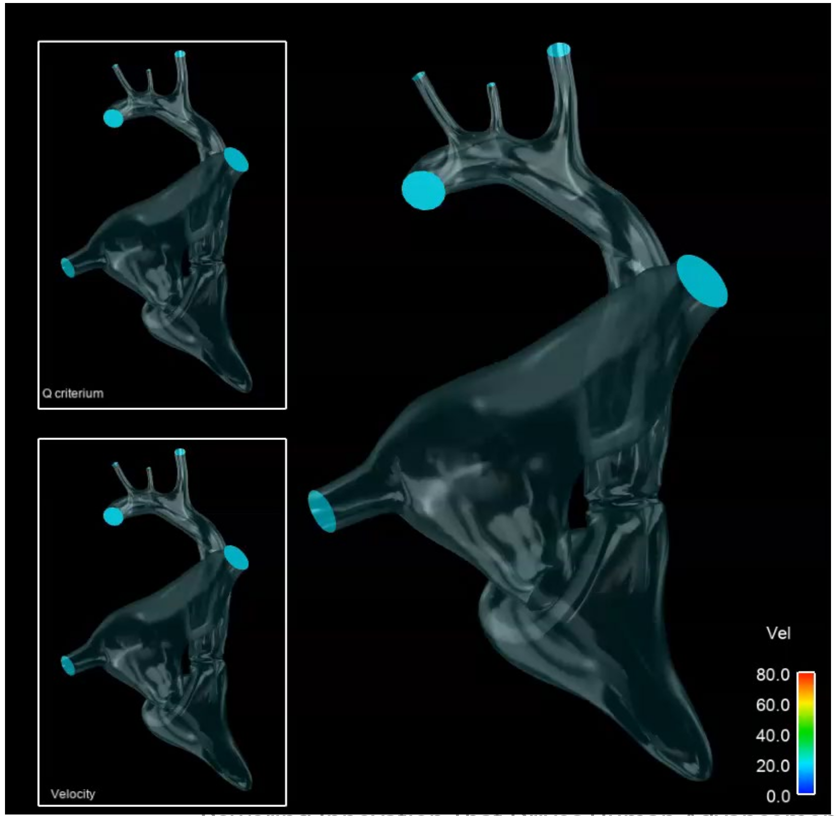
- Species concentrations can permeate through porous membranes and fabrics.



Cardiovascular Flows

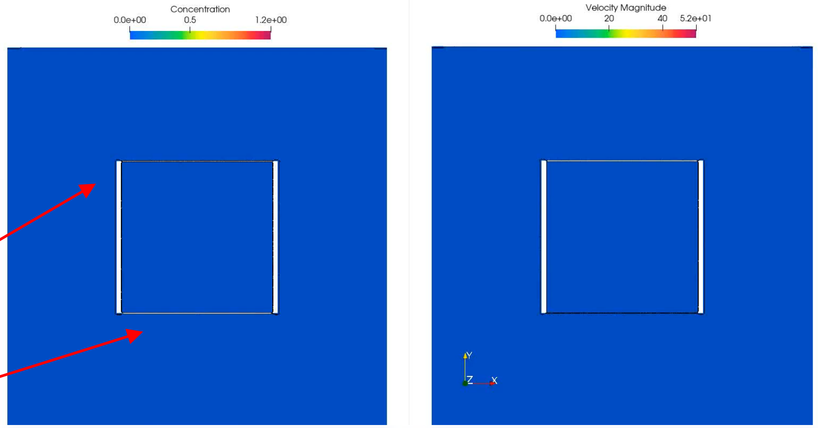
- Implementation/Improvement of the Generalized Moving Porous Regions (*ICFD_DEFINE_POROUS_REGION) to simulate Mechanical Heart Valves. The mechanical behavior is dynamically similar to real valves but with faster and simpler dynamics. A pair of pressure sensors can be located at any subdomain/compartment to control the opening and closing of the valves according to the pressure gradient between these subdomain (normally, across the valve itself). The sensors should be used jointly with *ICFD_CONTROL_TAVERAGE to avoid rapid oscillations of the pressure drop across valves.





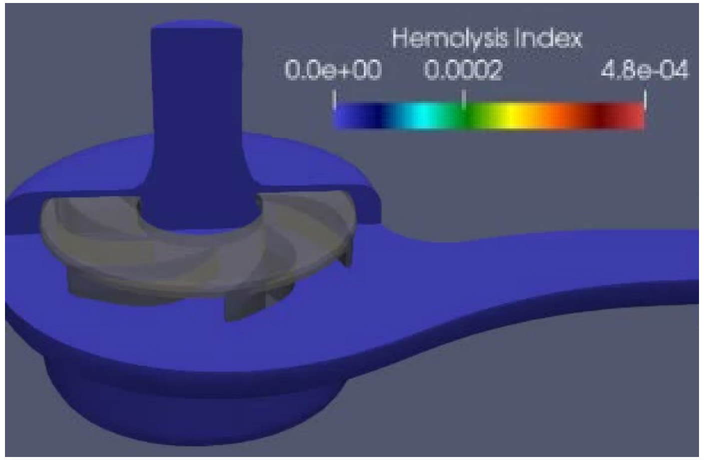
Flow Through Porous Membranes/Fabrics.

- Porous and non-porous (impermeable) membranes and fabrics can now be used simultaneously in the same model.



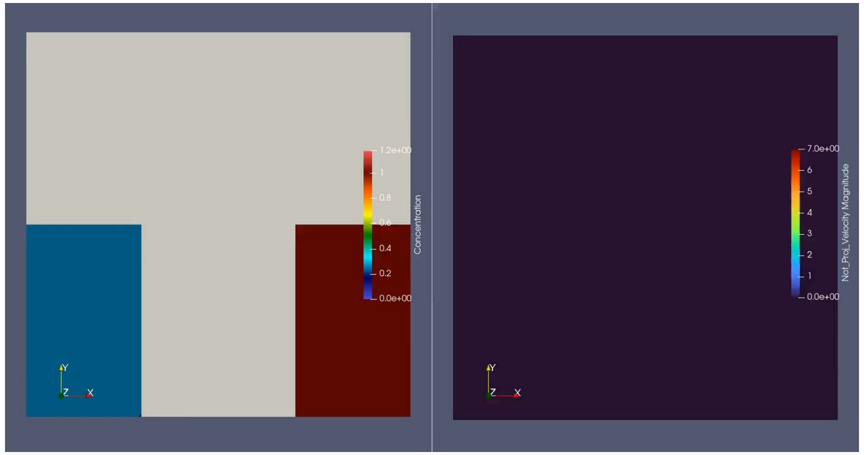
non-porous flexible membrane

porous rigid membrane



- Computing and Tracking of the Hemolysis Index and Scalar Shear Stresses in vessels and implantations.

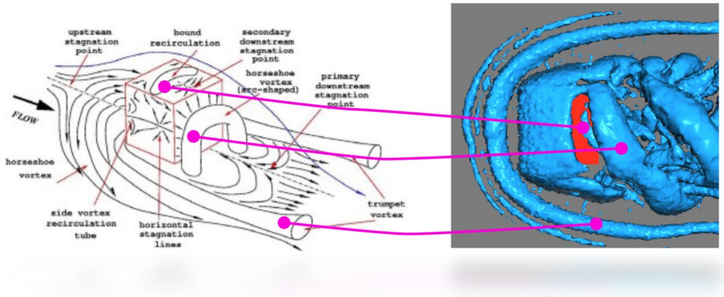
In collaboration with Incor/HC/Univ. San Pablo/UNICAMP. (Dr. Cestari/Dr. Oliveira)



- Two fluids model coupled with species transport. Air/Water system with a dispersed species.

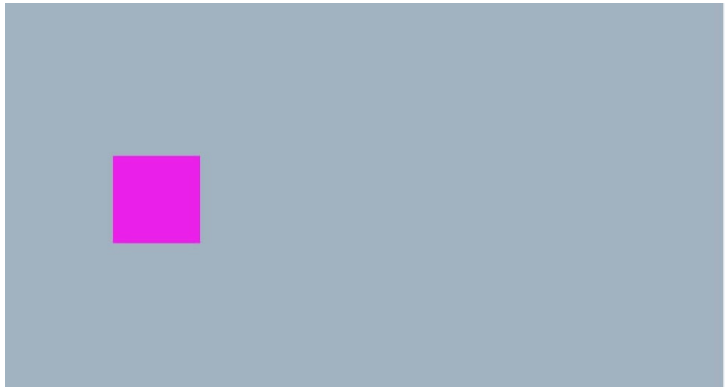
Immersed Interface Method

- Based on the Resistive Implicit Immersed Surface (RIIS) method [1].
- Good agreement between body fitted and immersed method.
- Available in MPP, 3-D only.
- Allows Fluid Structure Interaction analysis.
- ICFD_CONTROL_IMMERSED and ICFD_CONTROL_DEM

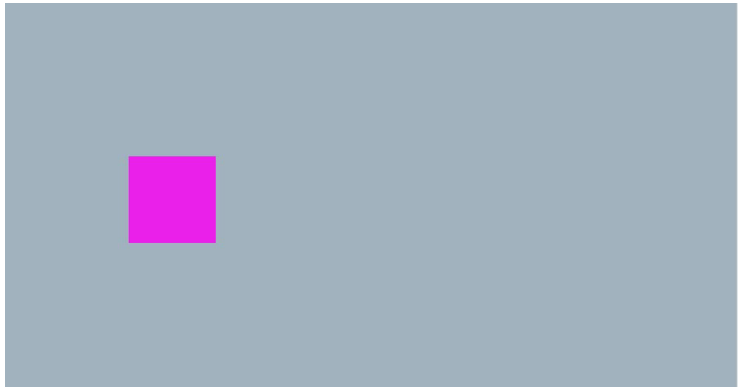


High Reynolds Bluff Body Benchmark. Re=40000

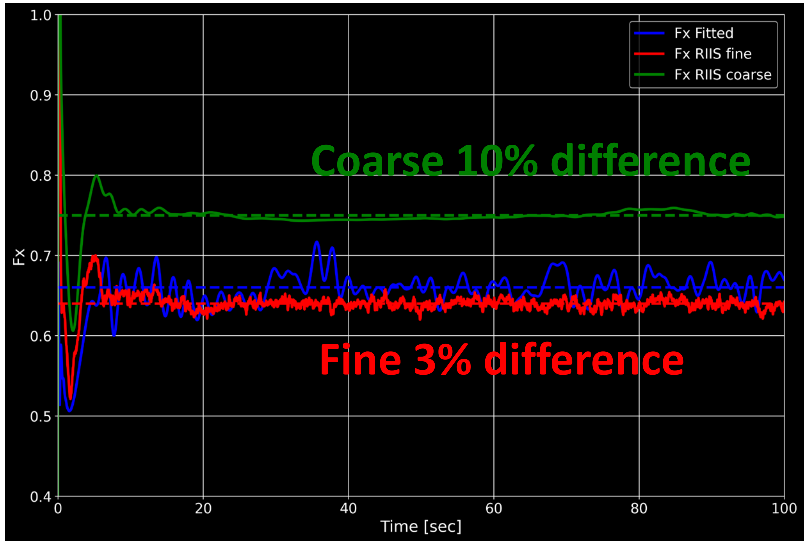
Fitted



Immersed Coarse



Immersed Fine



Computed force on X axis. Good agreement with the body fitted approach.

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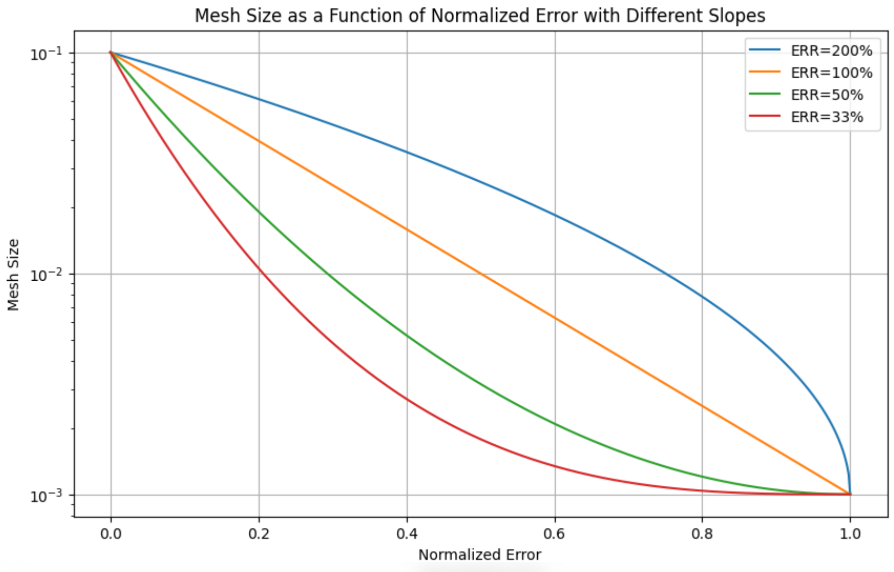
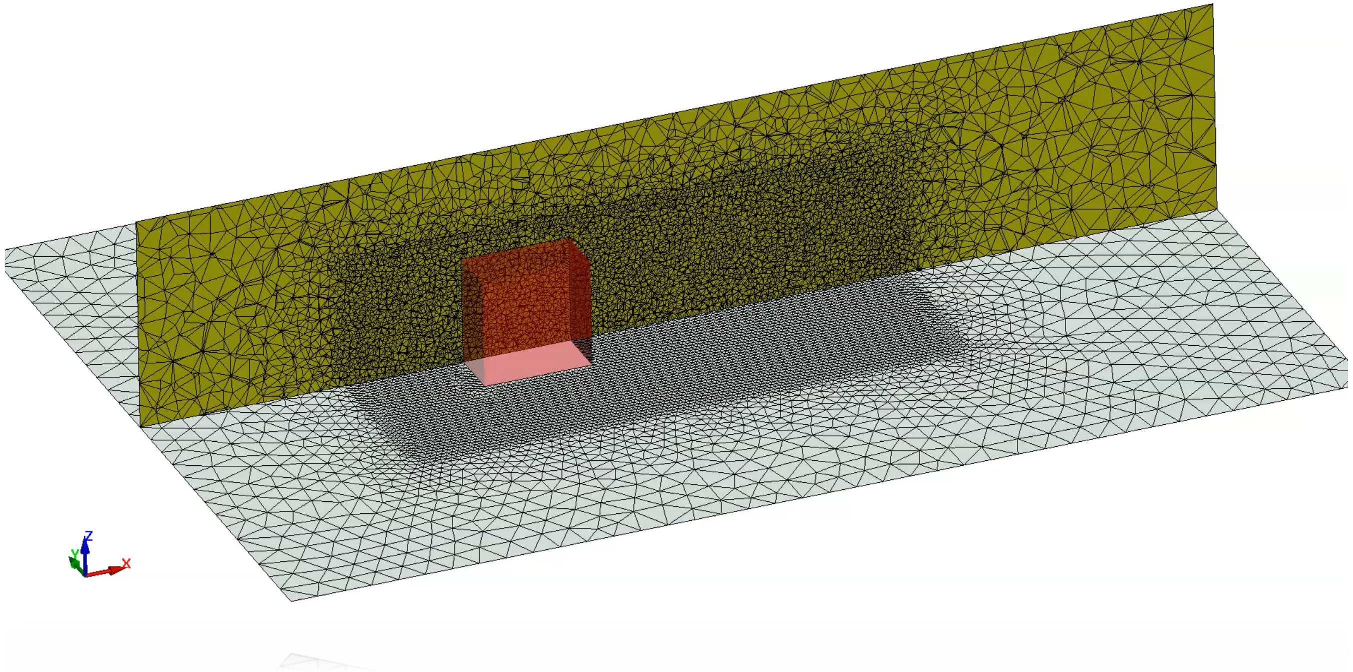
[1] Fernandez MA, Gerbeau JF, Martin V (2008) Numerical simulation of blood flows through a porous interface. ESAIM: Mathematical Modelling and Numerical Analysis 42(06): 961–990.

Adaptive Meshing: Improvements

- Improved stability for the time dependent mesh sizes. Smooth change of element numbers across time steps.
- Automatic detection of immersed and level set interfaces.
- Better control between min-max mesh size transitions from regions with larger to smaller errors (ERR card).





Immersed interface case with adaptive mesh refinement. Note the finer mesh close to the immersed interface and the smooth transition of element sizes.

Dual CESE

Compressible CFD solver based on the Conservation Element Solution Element (CESE) method

Supersonic flows over a porous canopy (2D)

- In order to investigate the influence of broadcloth porosity to supersonic flow field around a simplified parachute canopy, a simplified 2D test example is setup as following:
    - an arc canopy (a high porosity broadcloth PIA-C-7020D) is located in the middle of the fluid domain (see the sketch in Fig.1(a))
    - The upstream flow is a supersonic flow at M=2.0.
- Fig1(b) movie shows the numerical results.
    - Because of the porosity, some fluid flow is allowed to pass through the canopy, a higher density can be seen in the wake of the canopy.
    - The porosity acts as a sort of 'relief valve', allowing high pressure flow to pass through the canopy and prevent the excessive over-pressure that will make the flow more stable than that without porosity case.

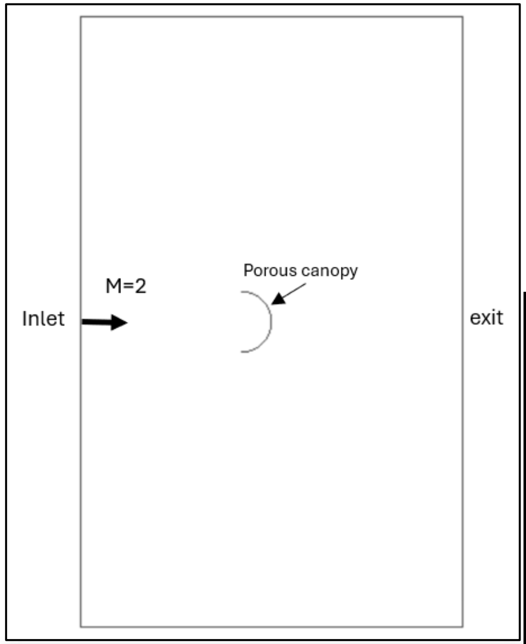


Fig.1(a)

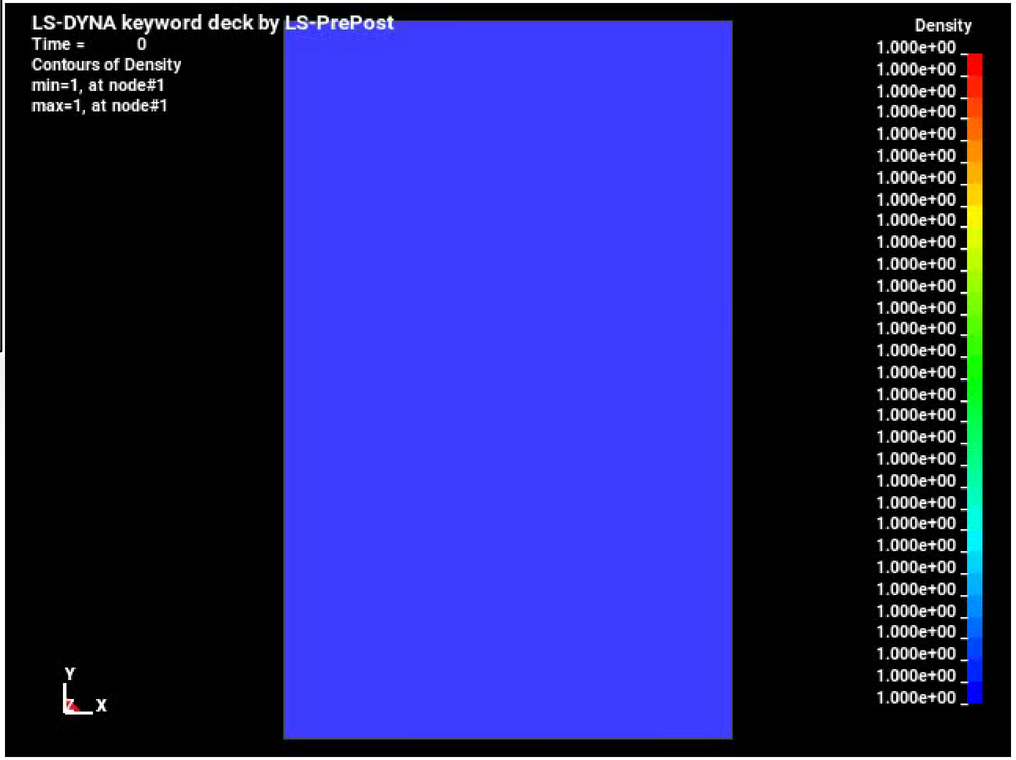


Fig.1(b)

Supersonic flows over a porous canopy (3D)

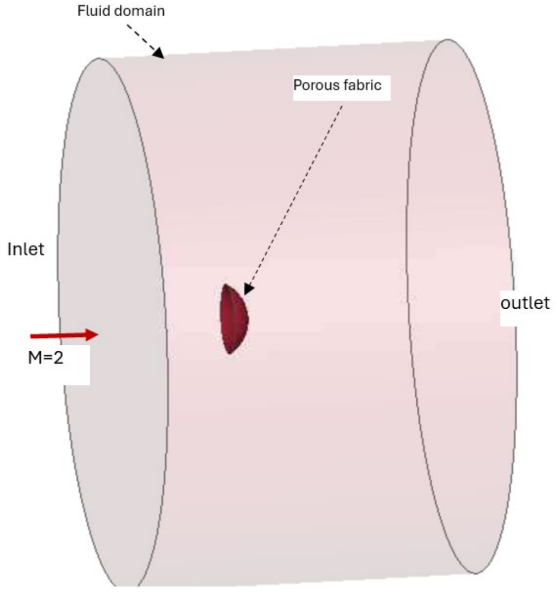


Fig.2(a)

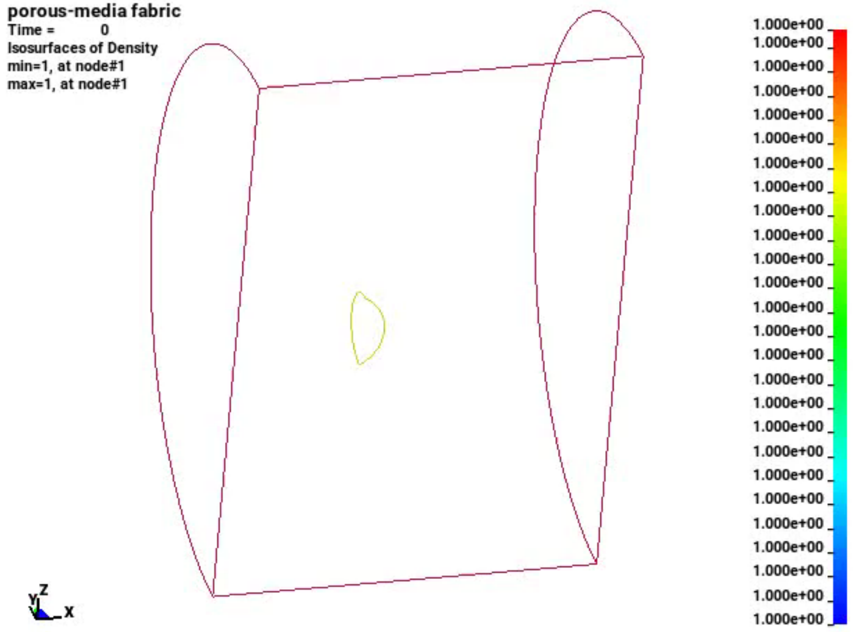


Fig.2(b)

- This is the extension of the above 2D example :
  - ➢ The flow initial, boundary condition, and canopy material setup is similar to the 2D case. (see left Fig.2(a))
  - ➢ The upstream flow is a supersonic flow at M=2.0. The fluid domain is divided into 1,151,920 hexahedron elements and the mesh near the cylinder axis is a little finer than that at the outer area of the fluid domain
- Fig2(b) numerical result shows the flow developing process (half of the fluid domain is shown).
  - ➢ 3D case flow is more stable than the 2D one . This is because of the 3D mesh is not fine enough (this means there will be more numerical damping), as well as due to 3D effects.

NVH

*FREQUENCY_DOMAIN_SSD: including residual vectors

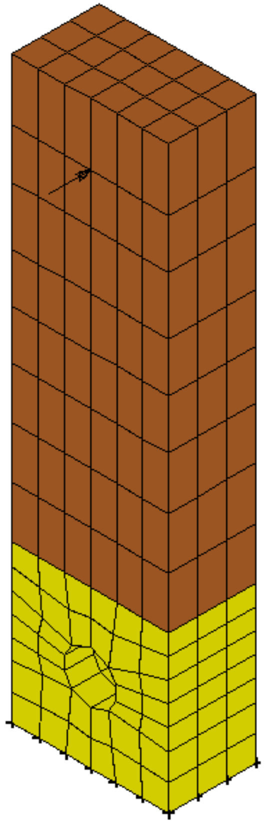
- Step 1: generate eigenmodes and residual vectors (Roger Grimes)

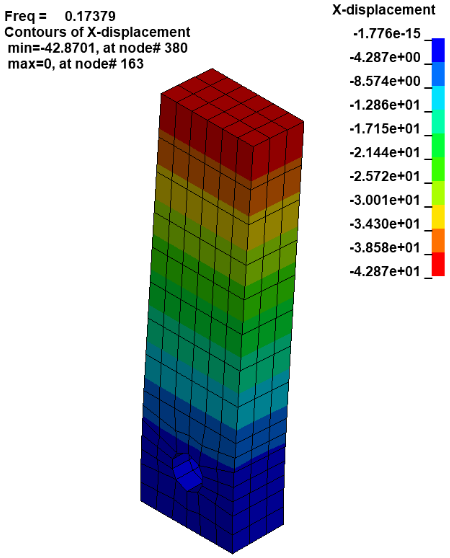
```
*CONTROL_IMPLICIT_GENERAL
$#  imflag       dt0    imform      nsbs       igs     cnstn      form    zero_v
         1  1.000000         2         1         1         0         0         0
*CONTROL_IMPLICIT_RESIDUAL_VECTOR
$#  resvec      neig     iparm
         1        50         1
*LOAD_NODE_POINT
$#     nid       dof      lcid        sf       cid        m1        m2        m3
       637         1     41011       1.0
*DEFINE_CURVE
$#    lcid      sidr       sfa       sfo      offa      offo    dattyp     lcint
     41011         0       0.0       0.0       0.0       0.0         0         0
$#                a1                  o1
                 0.0                 0.0
                 1.0                 1.0
*CONTROL_TERMINATION
$#  endtim    endcyc     dtmin    endeng    endmas
  1.000000         0     0.000     0.000     0.000
```

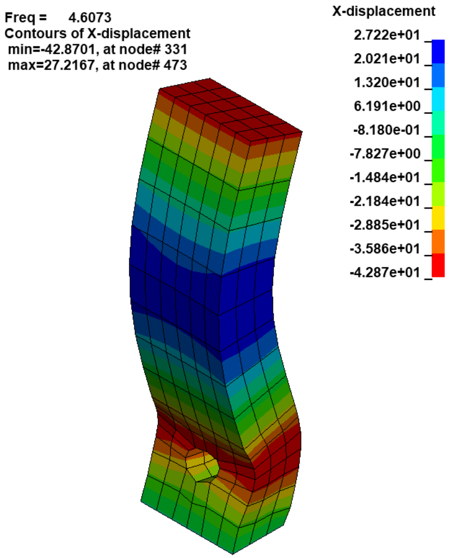
- Step 2: run SSD computation with eigenmodes and residual vectors

```
*FREQUENCY_DOMAIN_SSD
$#   mdmin     mdmax     fnmin     fnmax    restmd    restdp    lcflag
         1        50        0.   100000.         3         0         1
$#   rvmin     rvmax
         1         1
$#   dampf     lcdam     lctyp    dmpmas    dmpstf

$#                                                    nout     notyp      nova

$#     nid      ntyp       dof       vad       lc1       lc2       lc3       vid
       637         0         1         0       100       200
*FREQUENCY_DOMAIN_PATH
../residual.vector/d3eigv
*FREQUENCY_DOMAIN_PATH_RESIDUAL_VECTOR
../residual.vector/d3resvec
```

- Benefit: higher accuracy with limited eigenmodes

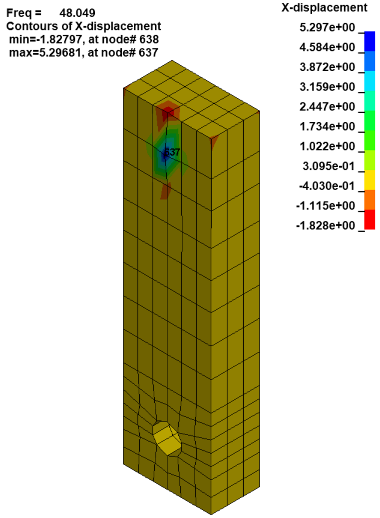






d3eigv Mode 1

Mode 7



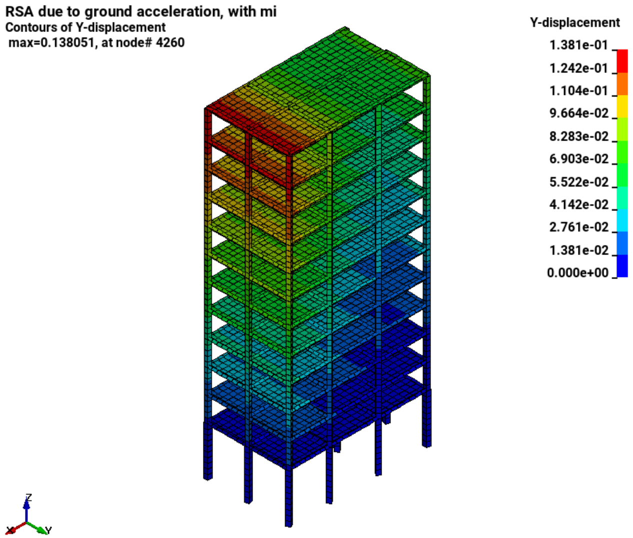
d3resvec

*FREQUENCY_DOMAIN_RESPONSE_SPECTRUM: missing mass correction

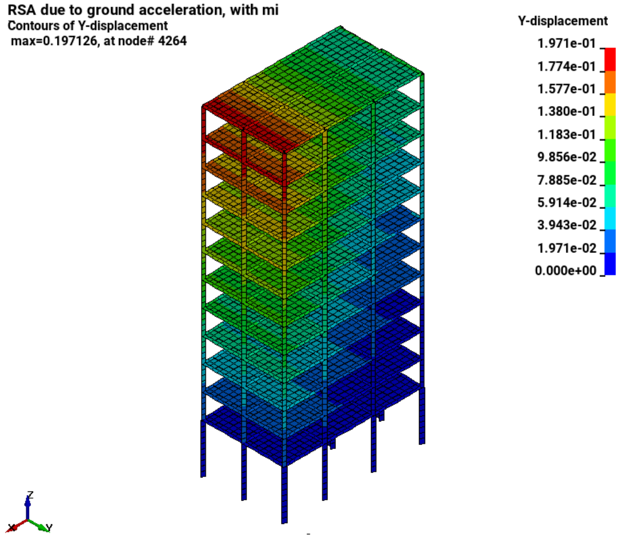
- In general, a mode superposition using a limited number of modes will miss some mass.
- For response spectrum analysis, static correction can be made by adding static load response for the missing mass.
- Missing mass load is provided by ZPA-∑(mode load).

```
*FREQUENCY_DOMAIN_RESPONSE_SPECTRUM_MISSING_MASS_CORRECTION
$#   mdmin     mdmax     fnmin     fnmax    restrt     mcomb    relatv
         1       200        0.      100.
$#     zpa    filename
       2.0   case1.d3plot
$#   dampf    lcdamp     ldtyp    dmpmas    dmpstf
      .001
$#   lctyp         dof   lc/tbid        sf       vid      lnid     lntyp    inflag
$        1         1     27000        0.
         1         2     27000        0.
$        1         3     27000        0.
*DATABASE_FREQUENCY_BINARY_D3SPCM
$#  binary
         1
```

Without missing mass correction



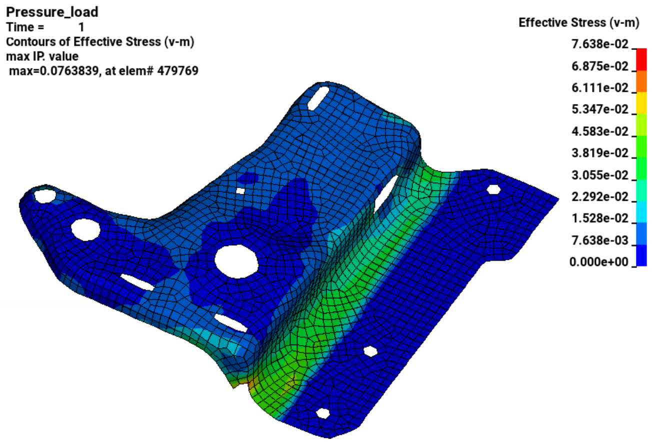
With missing mass correction



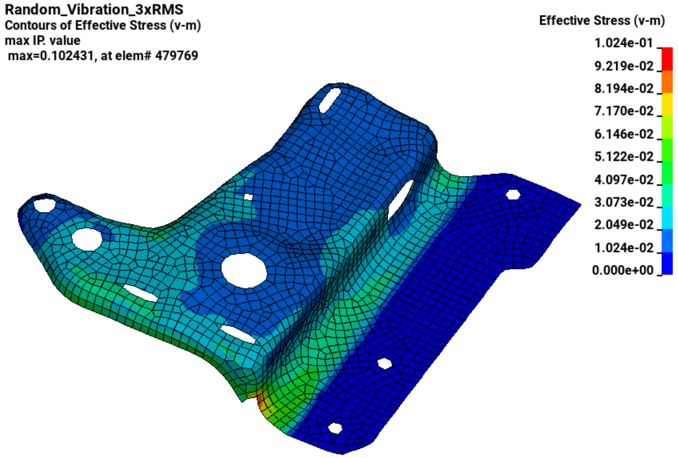
*FREQUENCY_DOMAIN_RANDOM_VIBRATION: new d3rms file

- User wants to do failure analysis using stress in prestressed random vibration
- Total stress is the sum of stress in random vibration and prestress
- In the past, 3-sigma (rms) rule was used.
- New d3rms file includes:
  - State 1: RMS response
  - State 2: 3-sigma + prestress
  - State 3: 3-sigma + |prestress|

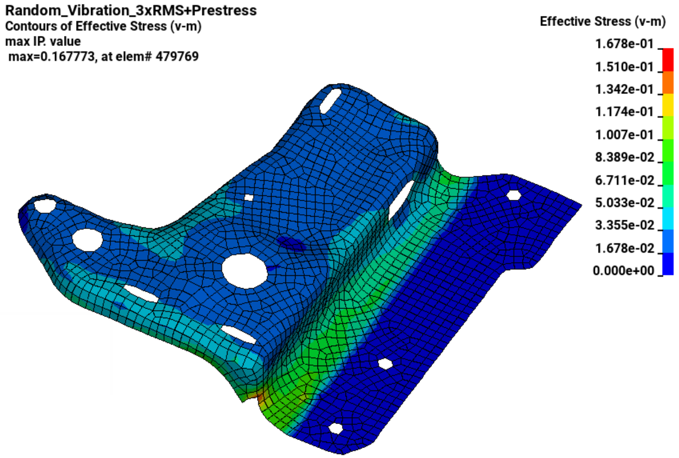
Prestress (d3plot)



3-sigma only (max: 102 Mpa)



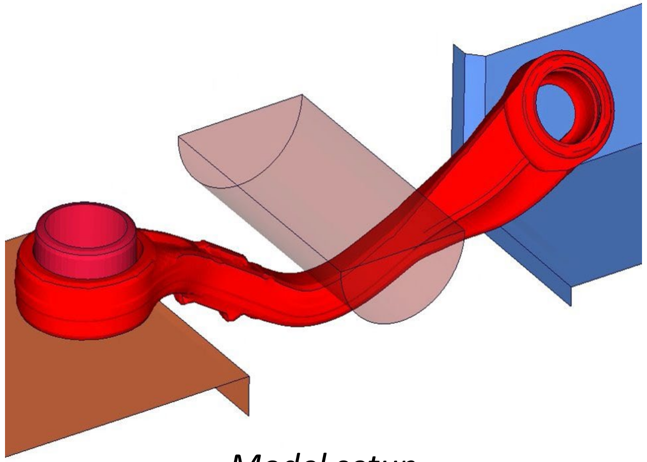
3-sigma + prestress (max: 168 Mpa)



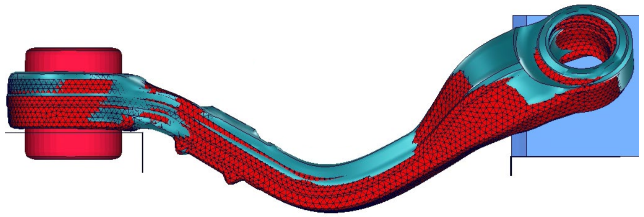
IGA

Isogeometric Analysis

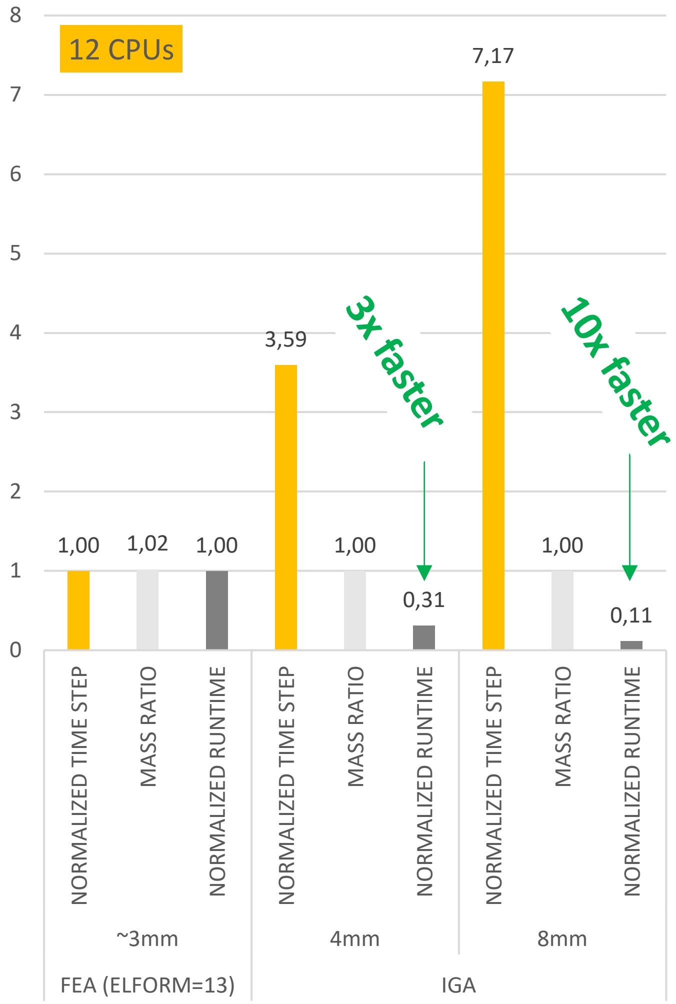
A note on trimmed solids

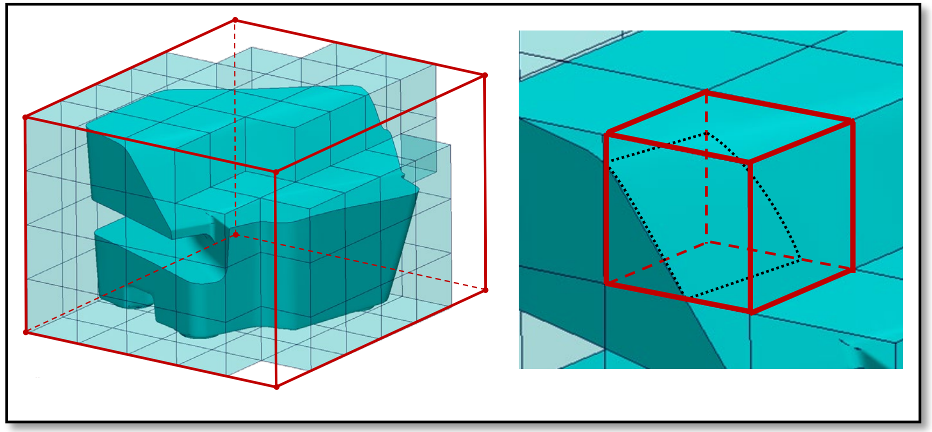


Model setup

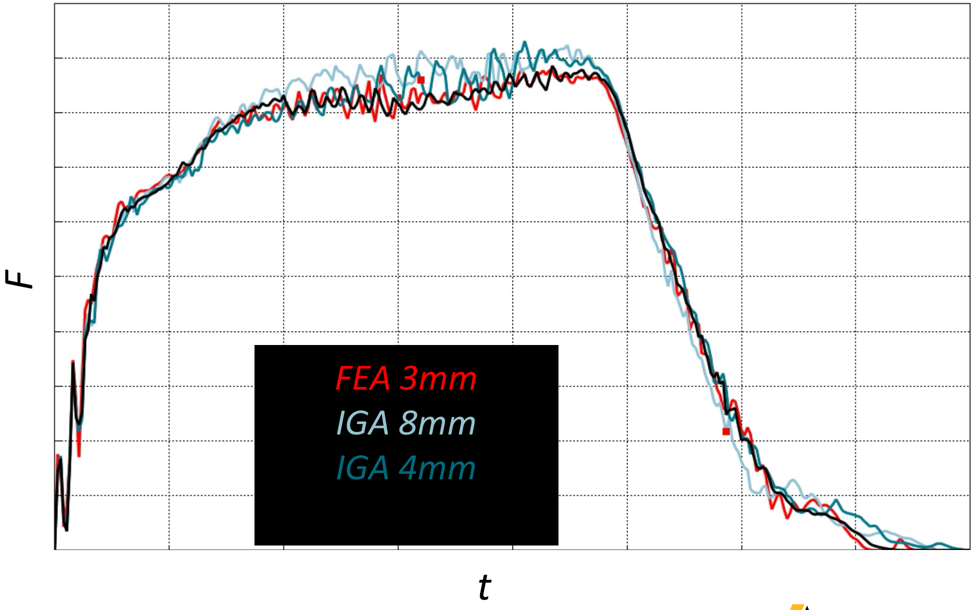


Deformation plot overlay
FEA 3mm vs. IGA 8mm

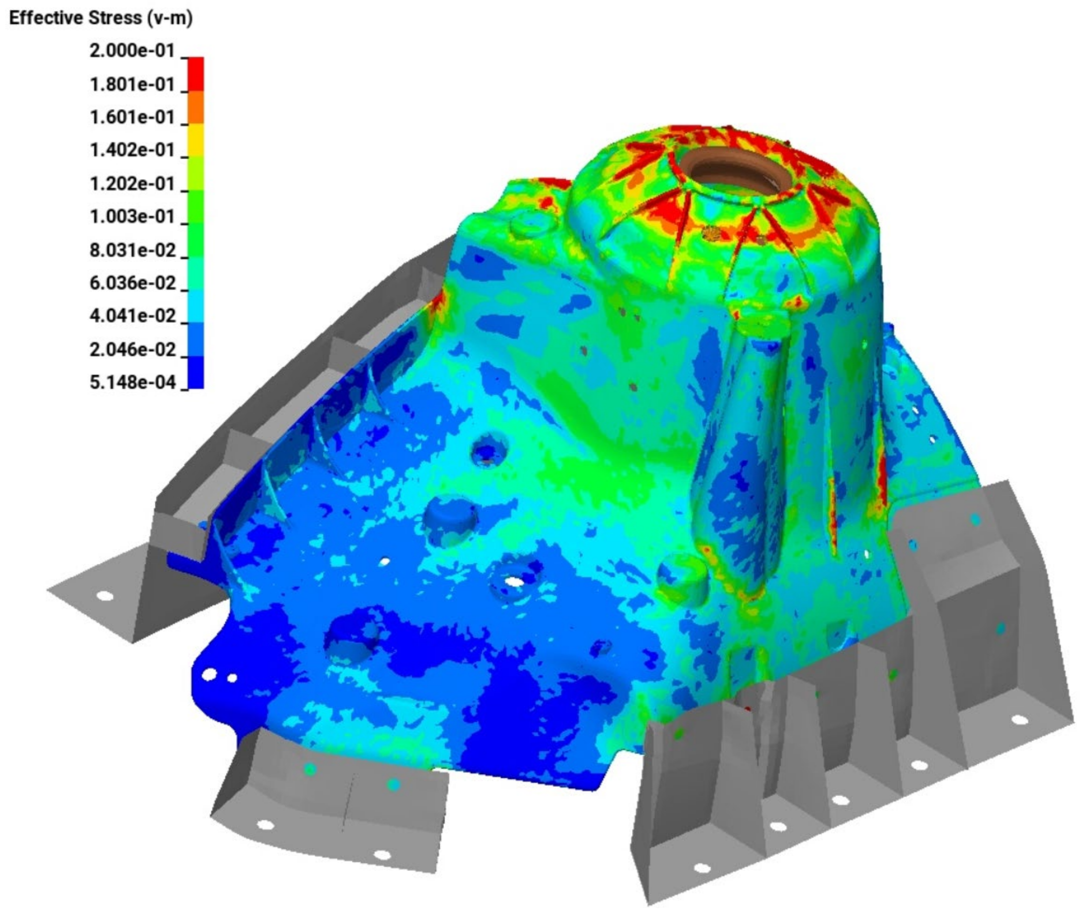




Prototype capability for testing and evaluation in R16. Please contact Livermore for more details.



Included features for trimmed solids

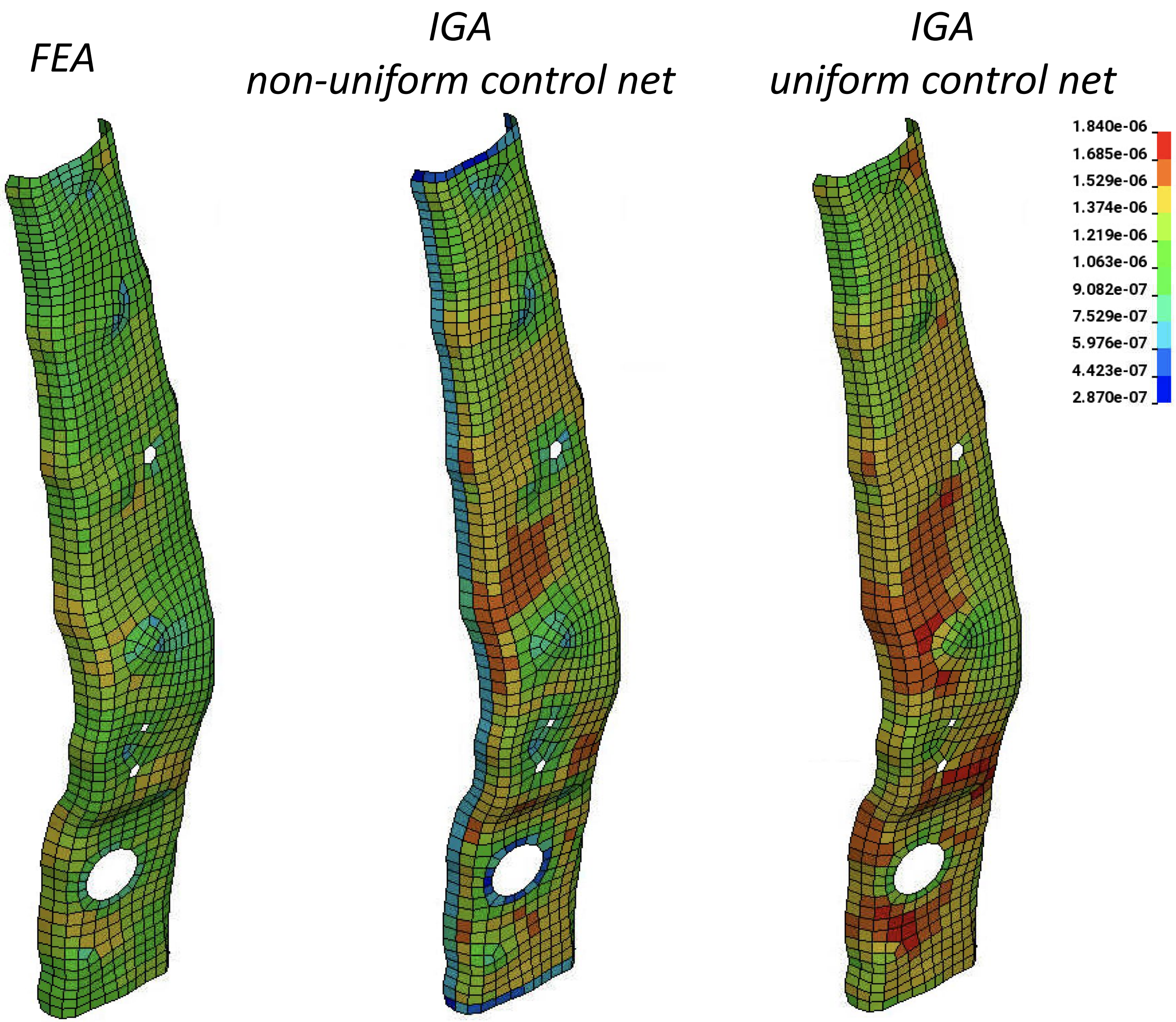


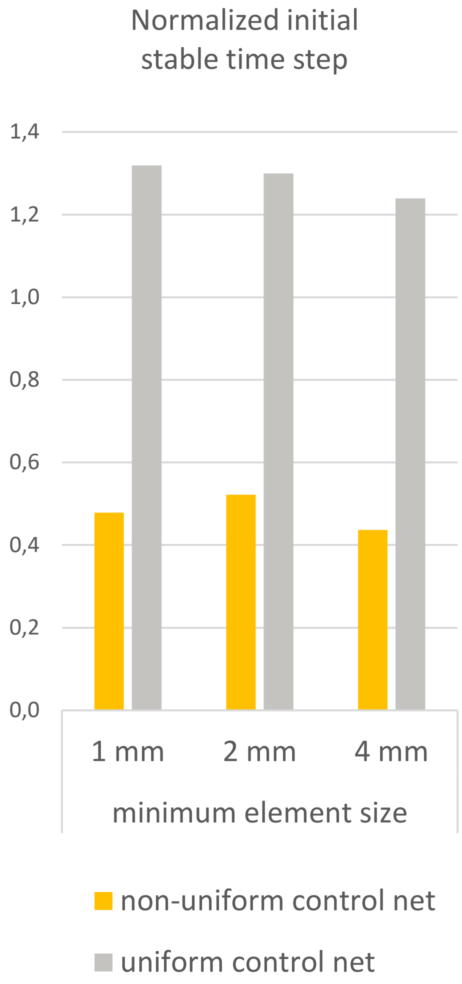
courtesy of General Motors

Prototype capability for testing and evaluation in R16. Please contact Livermore for more details.

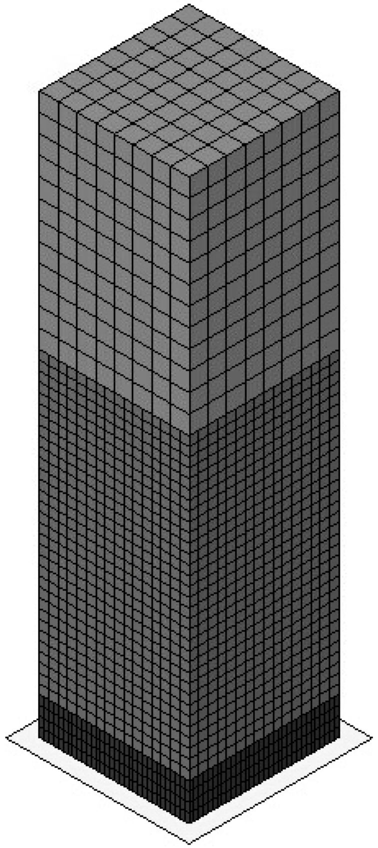
- *IGA_POINT_UVW
- *CONSTRAINED_NODAL_RIGID_BODY
- *CONSTRAINED_EXTRA_NODES
- *CONSTRAINED_SPR2/3

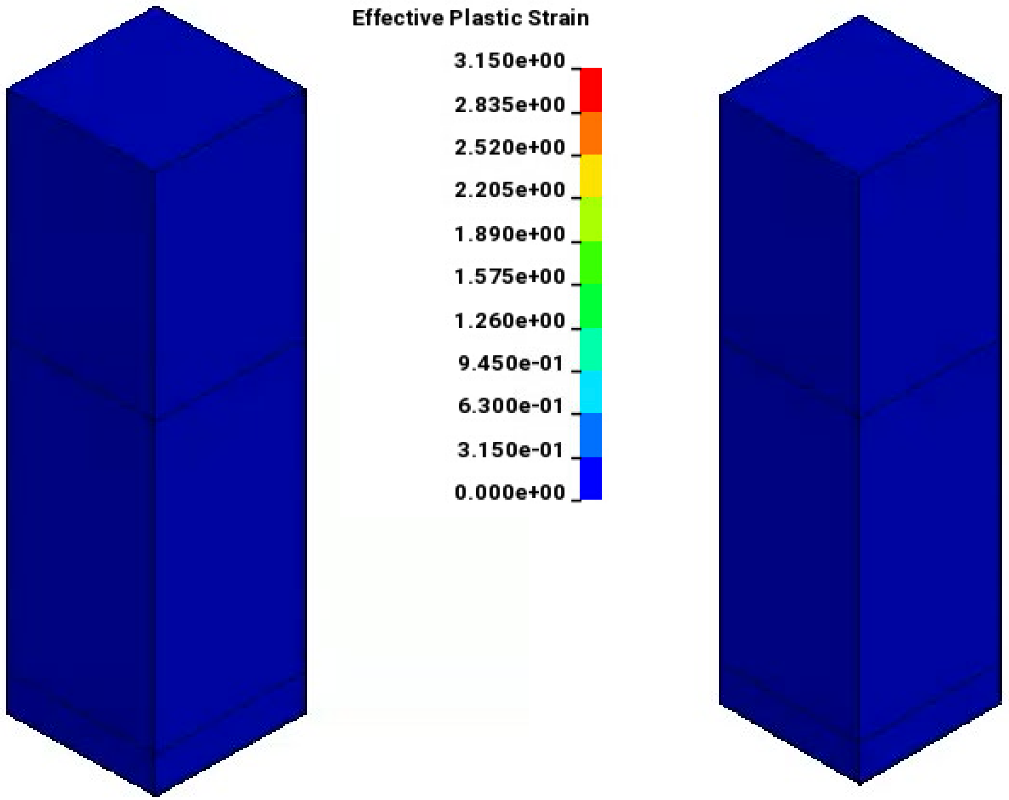
Unstructured splines - a note on stable time step



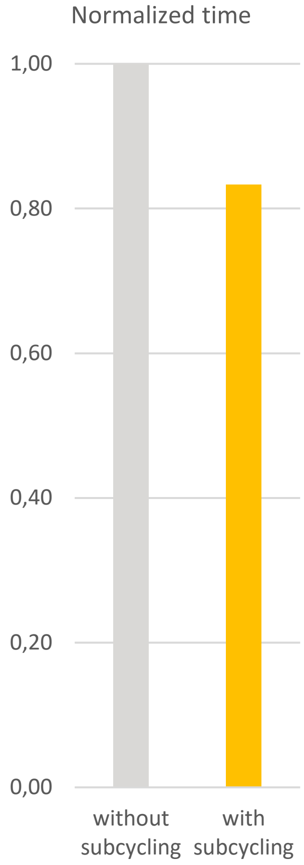


Subcycling





Effective Plastic Strain
3.150e+00
2.835e+00
2.520e+00
2.205e+00
1.890e+00
1.575e+00
1.260e+00
9.450e-01
6.300e-01
3.150e-01
0.000e+00



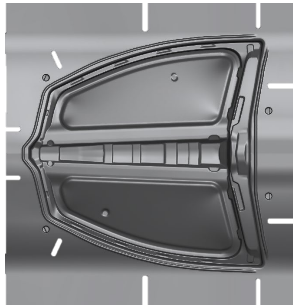
Normalized time
1,00
0,80
0,60
0,40
0,20
0,00
without subcycling
with subcycling

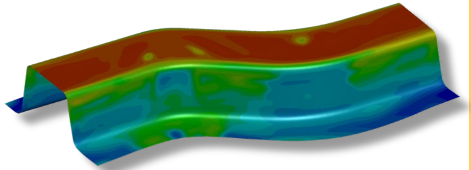
Ansys Forming

Ansys Forming

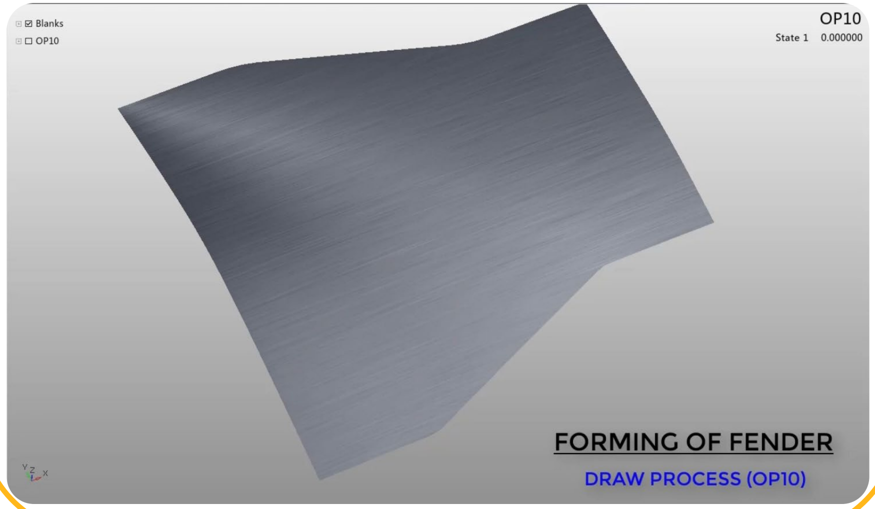
Cold/Hot Forming

- Blanking
- Drawing
- Gravity Loading
- Trimming
- Springback
- Lancing
- Clamping
- Flanging/Restriking



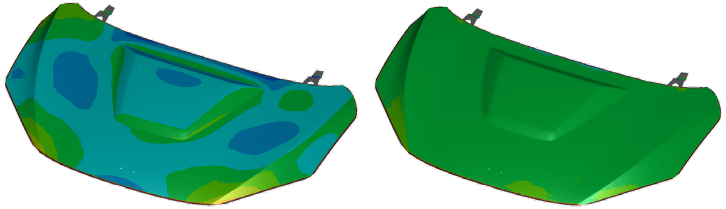


Dedicated Platform for Multi-Stage Stamping Simulations



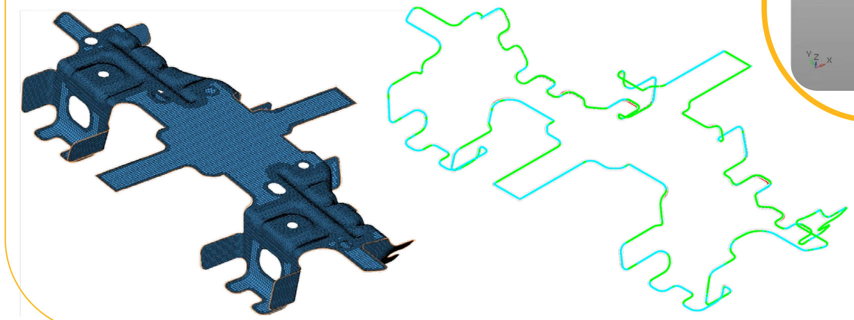
Springback Compensation

- Automatic Iteration
- Automatic Compensation for Draw Die
- Separate Coordinate Systems for Springback & Draw



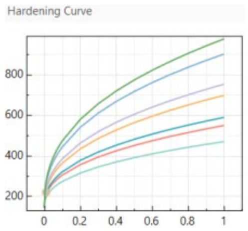
Trim Line Development

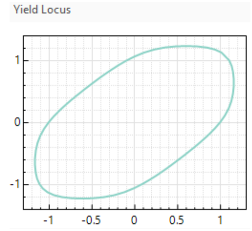
- Iterative Method
- Fast Convergence: 2-3 Iterations

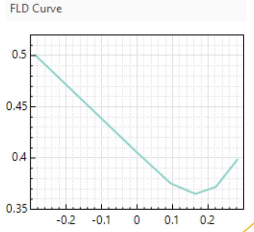


Dedicated Material Editor & Library

- Yield Locus
- Hardening Curve
- FLD Curve
- Support Most Stamping Related Materials





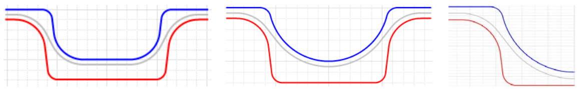


Ansys Forming

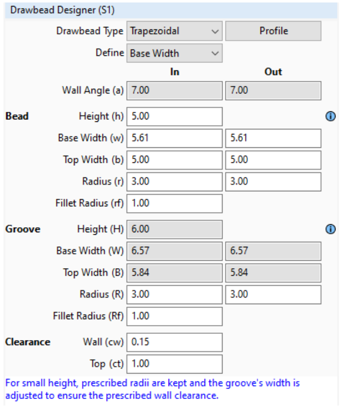
Drawbead Design & Modeling

- Drawbead Profile Design
- Bead Force Estimation
- 3D Bead Generation

Trapezoidal Round Step



Pre-defined Bead Profiles

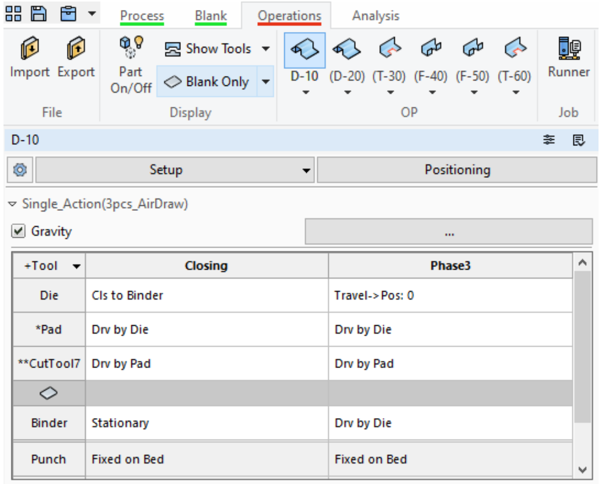


Bead Profile Designer

Transition Bead

Seamless Integration of Pre-/Post-Processing & Solver

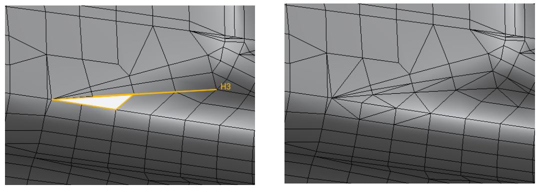
- Intuitive, Easy-to-use
- Accurate
- Highly Efficient
  - Automatic Contact Move
  - Smart Adaptivity
  - Optimized Process Settings
- Robust
- Auto Job Submission



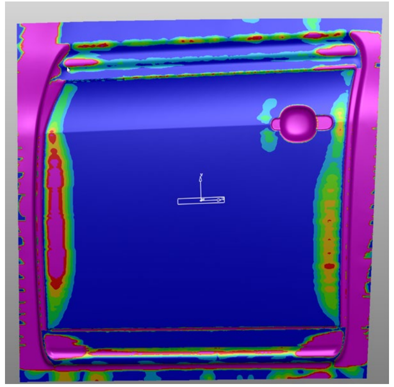
Process Definition Interface

Innovative Specialized Features

- Mesh Check & Repair
- Surface Defect Analysis
- In-Core Mesh Adaptivity
- Mesh Regeneration
- Variable Friction



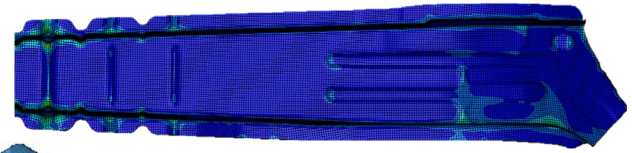
Bad Mesh Auto Fix



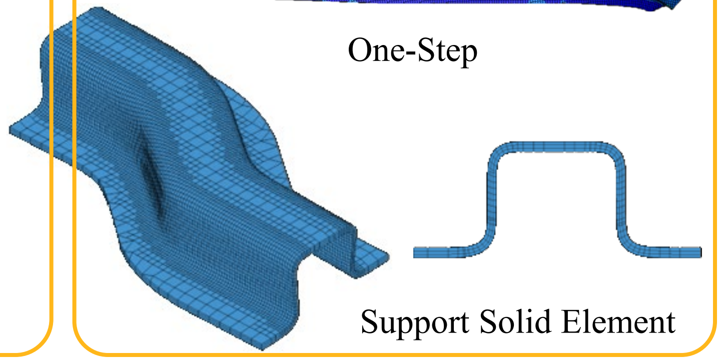
Surface Defect Evaluation

Future Development

- Maintenance of existing features
- Springback Compensation for line dies and restrike dies
- Unfolding flanges (One-step)
- Solid Elements
- Table Hemming (first step for assembly)
- Improved Binder model
- Die Face Design (and CAD Handling)
- Enhanced material models
- More material data
- Auto/Semi-auto Reporting
- Interoperability with other Ansys Tools (crash, Fatigue, optiSlang)



One-Step



Support Solid Element

LS-PrePost

LSPP

LS-PrePost Version Overview

- LS-PrePost is delivered *free* with LS-DYNA. As of today, still ***NO*** license key needed to run LS-PrePost
- LSPP 4.11.9 (2024R2) is the current released version. Will continue to have bugs fixed
- LSPP 4.12 (2025R1) is the development (Beta) version
- One can download LS-PrePost from:
  https://ftp.lstc.com/anonymous/outgoing/lsprepost/4.11/ (2024R2)
  https://ftp.lstc.com/anonymous/outgoing/lsprepost/dev/ (2025R1)
- LS-PrePost is developed on Windows and ported to Linux…
  - Windows - LS-PrePost-4.10.8-x64-26Oct2023_setup.exe
  - Linux - lsprepost-4.10.8-common-26Oct2023.tgz
  - Apple Mac - We will not support Apple Mac in after ver. 4.10

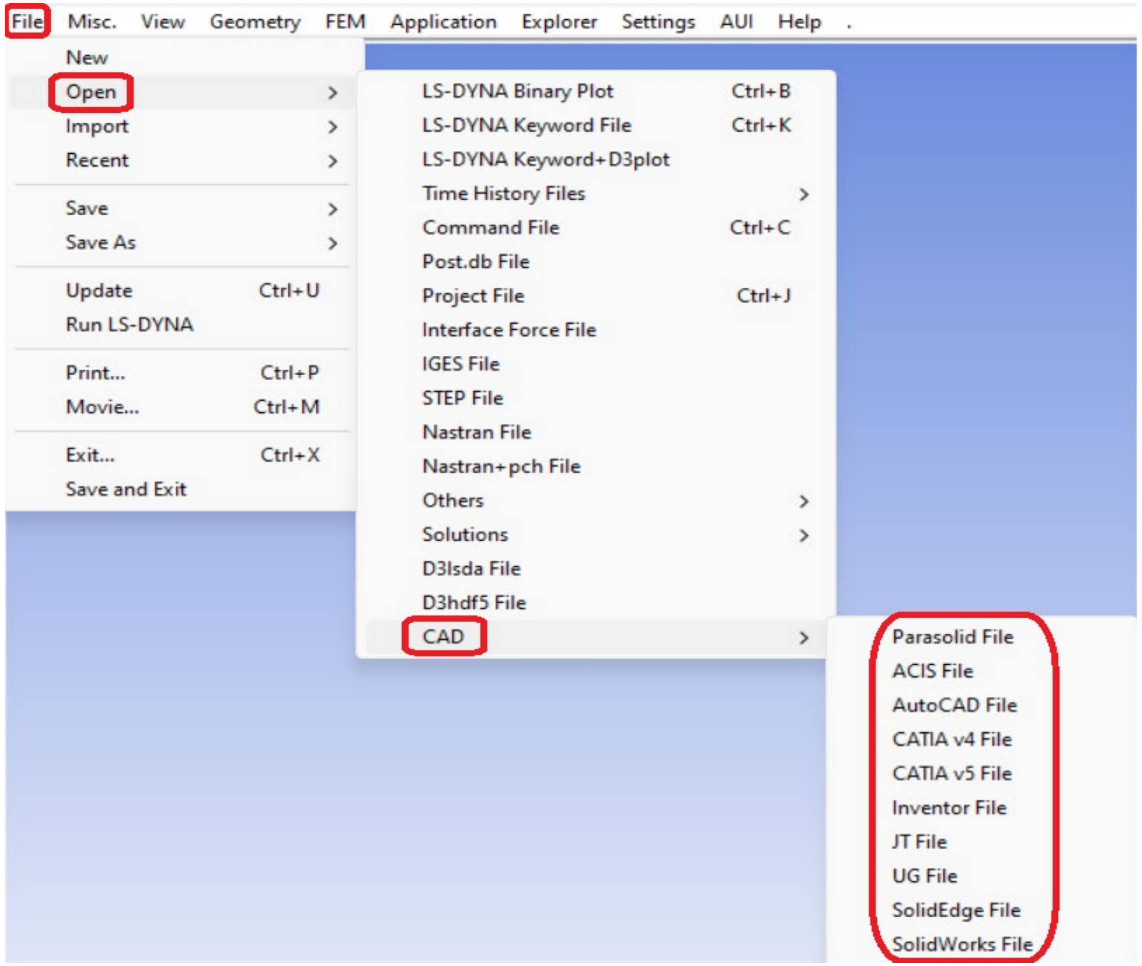
CAD: Support various CAD file formats import

- Must download LSPP_Translator from:

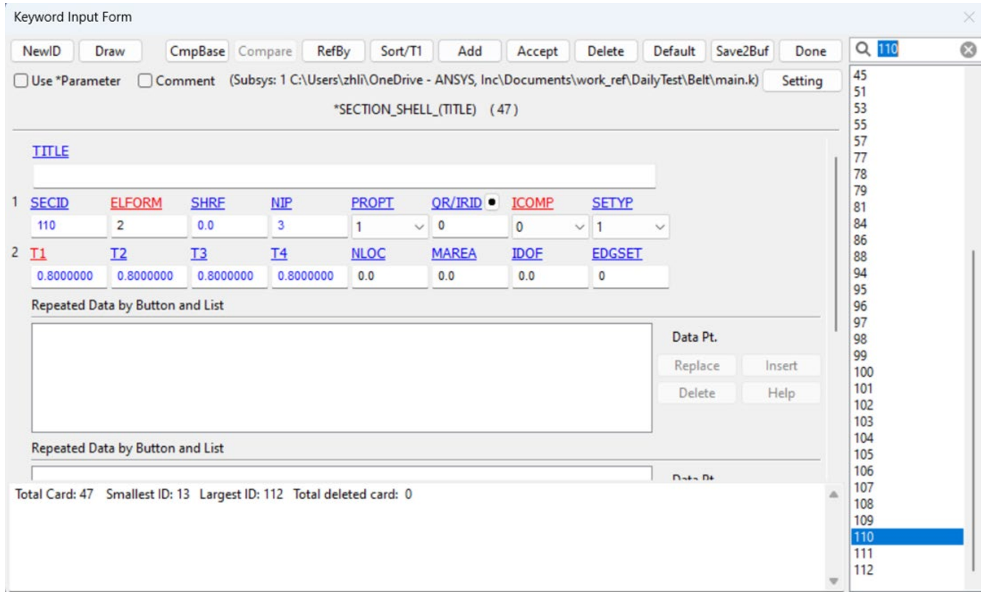
https://ftp.lstc.com/anonymous/outgoing/lsprepost/dev/LSPP_Translator.zip

Supported formats are:

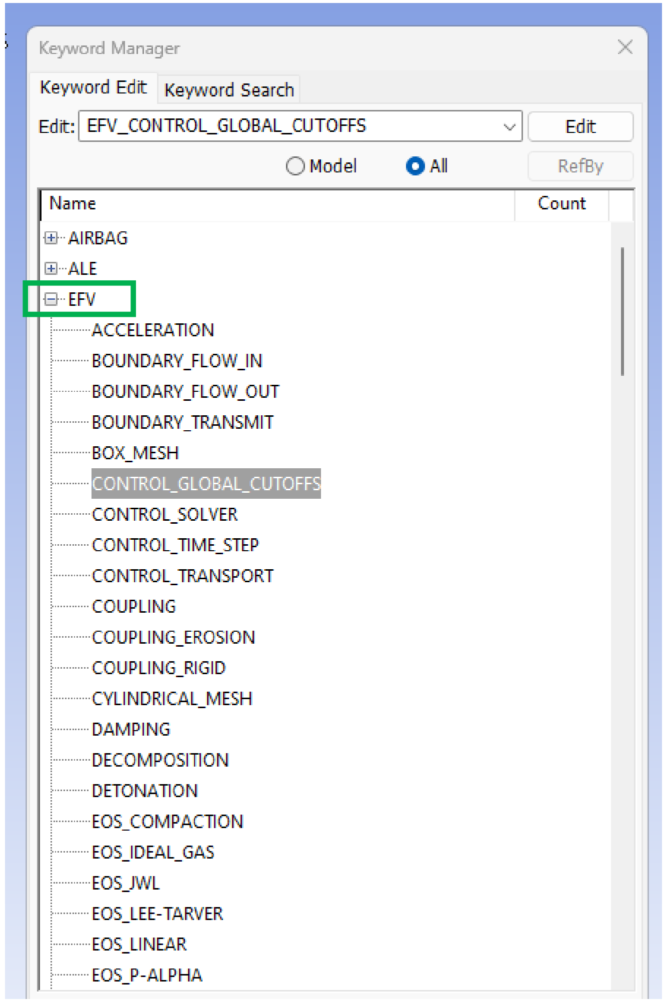
- Parasolid File
- ACIS File
- AutoCAD
- CATIA V4/V5
- Inventor
- JT
- UG
- SolidEdge
- SolidWorks



New Keyword Editing Features



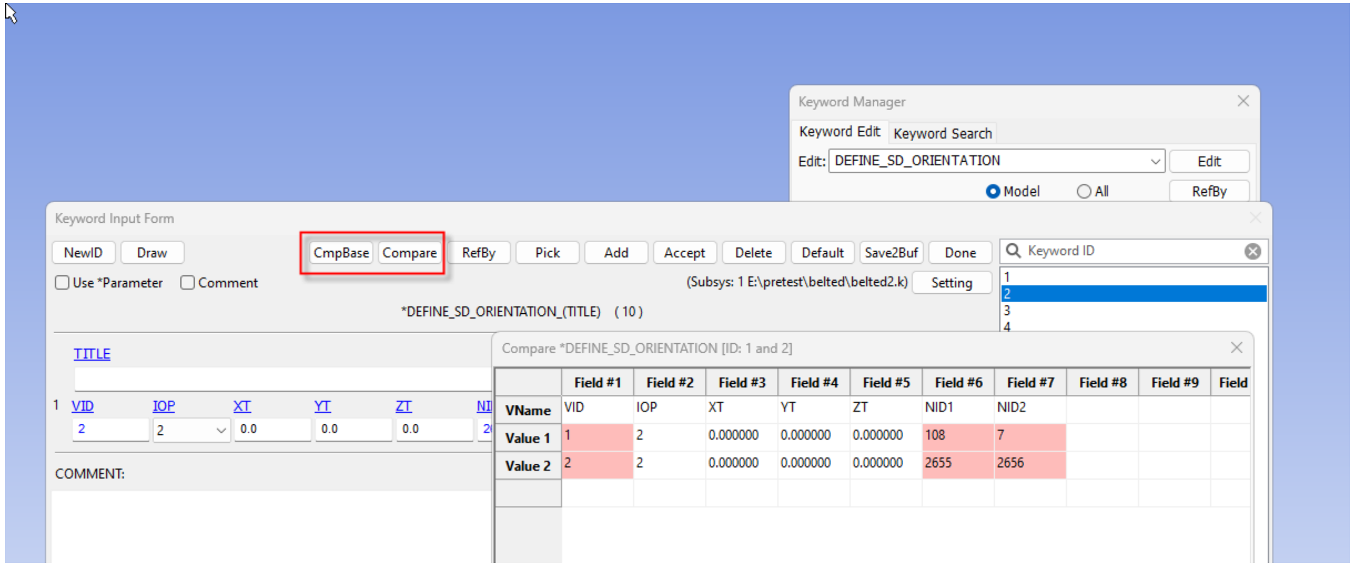
Search keyword by ID



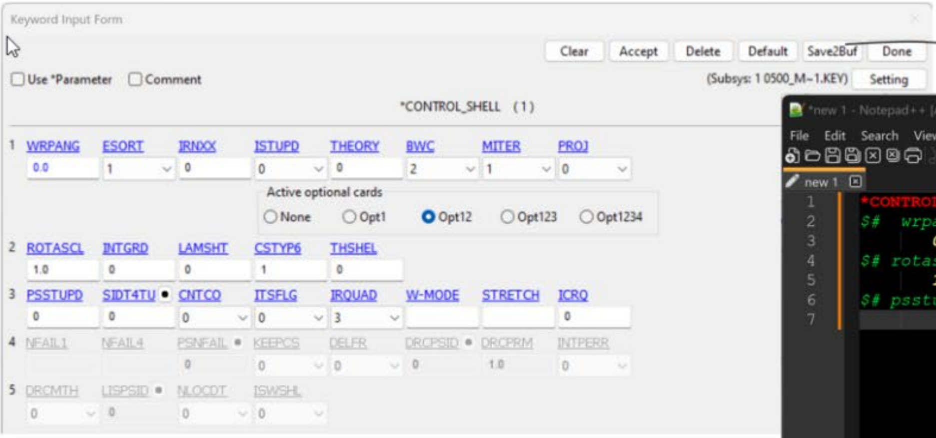
Support all **EFV** (**E**ulerian **F**inite **V**olume, previously known as **AutoDyn**) Keywords

New Keyword Editing Features

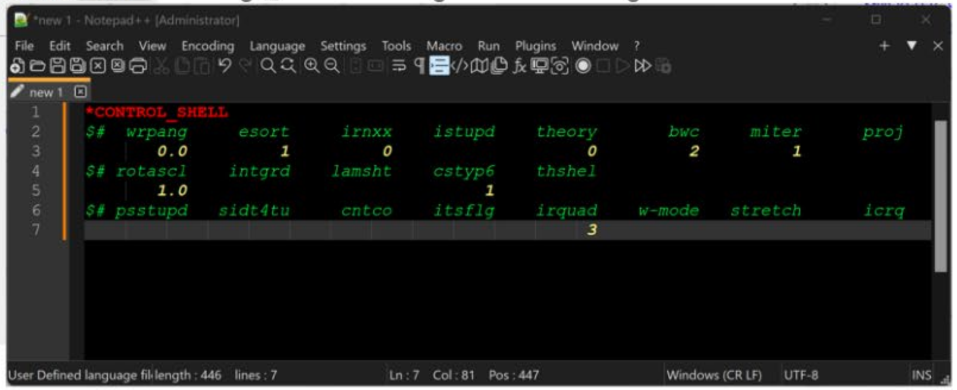
Compare 2 keyword data within the same model



Save2Buf option saves the current keyword into the buffer



Example with Notepad++ editor



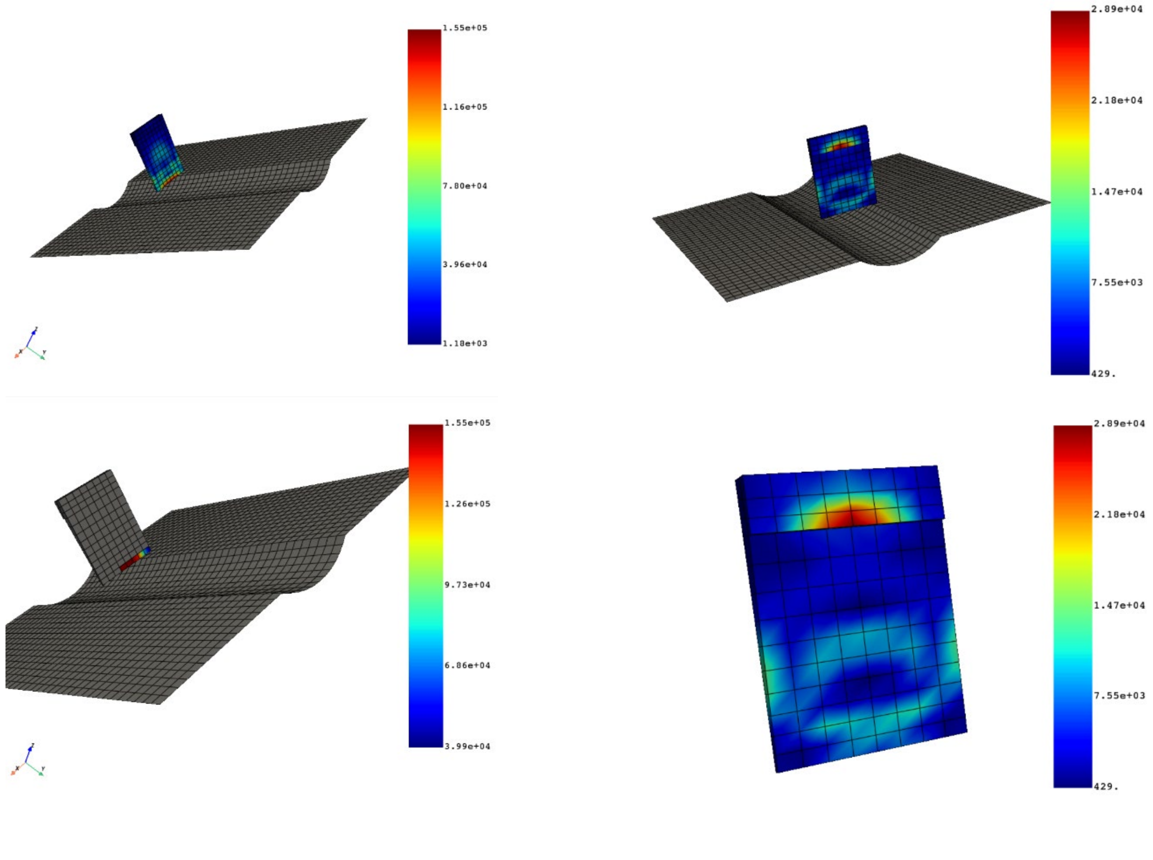
DPF (Data Processing Framework) LS-DYNA PlugIn

- Used to extract LS-DYNA results from d3plot files and binout files
- Advantage of DPF-LSDYNA
  - Easy to get the model information
  - Easy to get the variables using operators
  - Easy to fringe variables
  - Easy to deal with the xy-ploting data for binout file
  - Support scoping(mesh, time, location, name_selection, shape)
  - Field is a self-describing piece of data
  - Powerful workflow
  - Easy to use

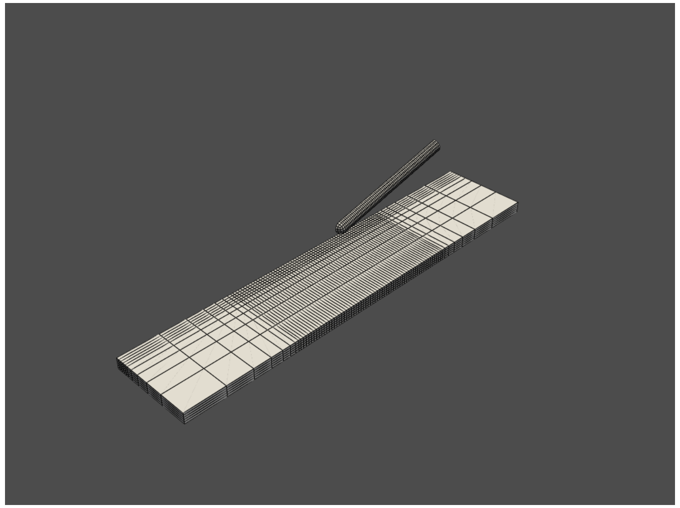
```
ds = dpf.DataSources()
ds.set_result_file_path(r'C:\ansys-dpf\lsdyna\Ans.Dpf.LSDYNAHGP\Ans.Dpf.LSDYNA.test\test_models\case18\test.d3plot')
model = dpf.Model(ds)
print(model)
model.plot()

em_current_op = model.results.em_cur()
em_current = em_current_op.eval()
em_current[20].plot()
```

DPF (Data Processing Framework) LS-DYNA PlugIn

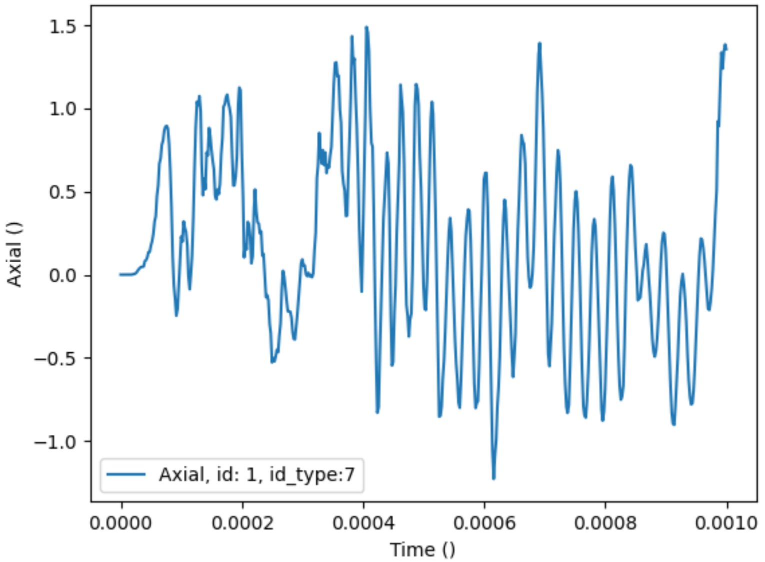
- **Fringe Results (scoping, by part)**



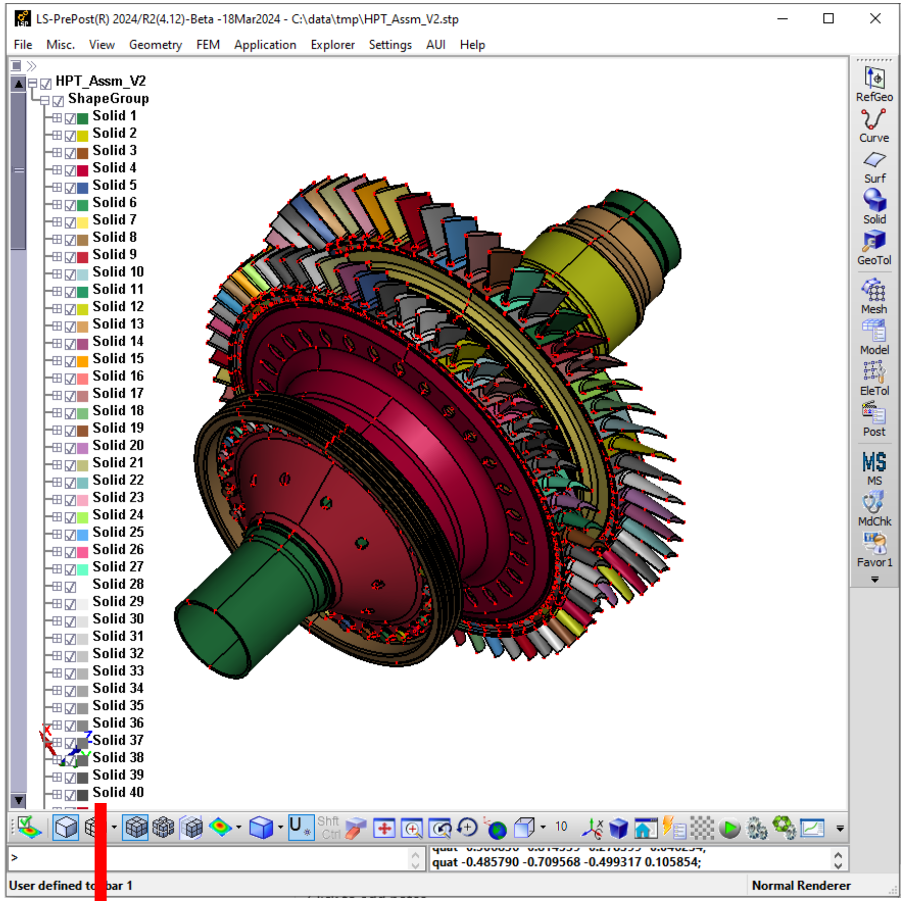
- **Adaptive Model**



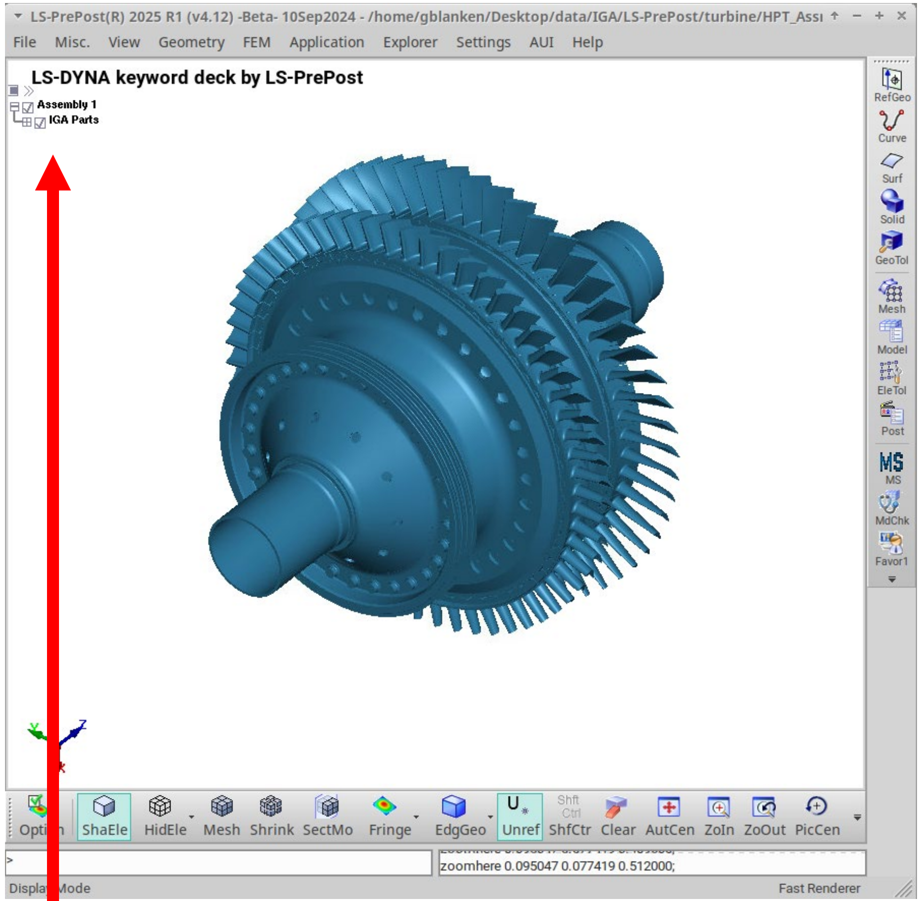
- **Binout**



Ongoing Work on IGA support in LS-PrePost – IGA Model Generation



CAD to IGA

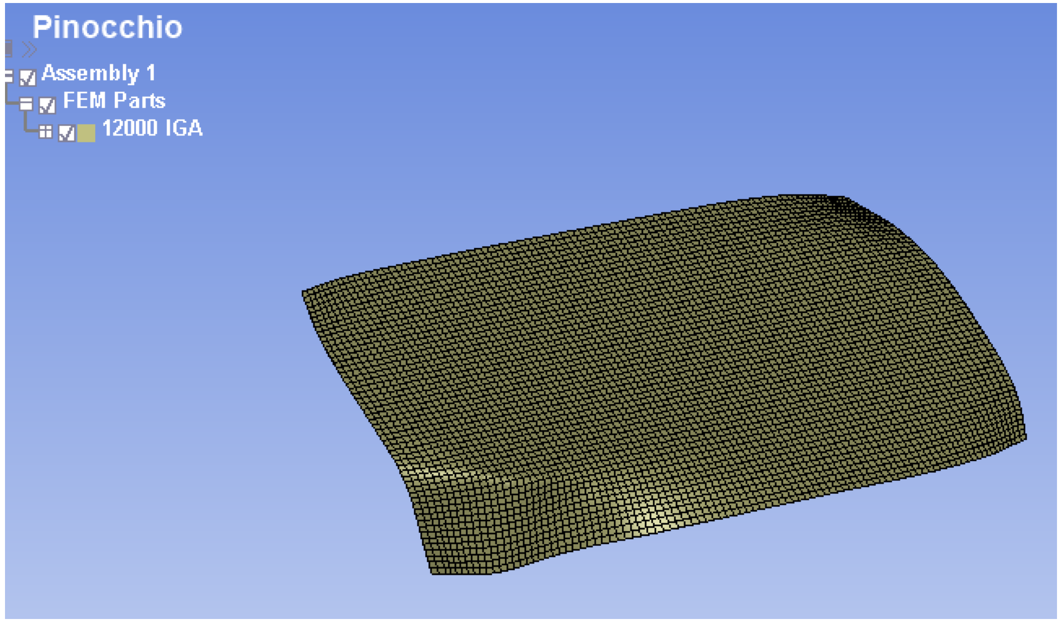


CAD entities translated to IGA entities (accessible in feature tree)

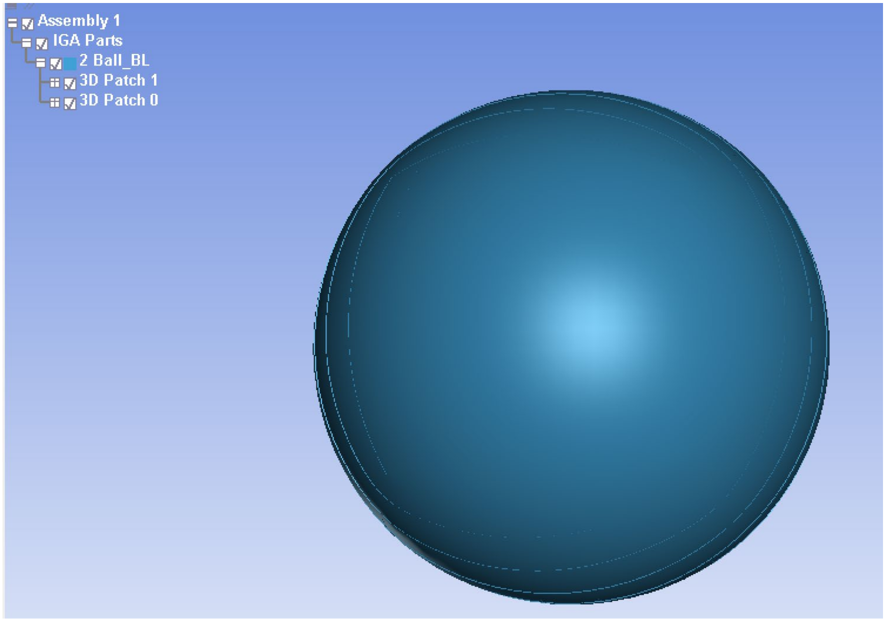
IGA Pre-Processing

Support IGA binary input in LSPP

LSPP supports the traditional ASCII keyword input as well as their hybrid counterparts where all *IGA keywords are included using the binary input format.



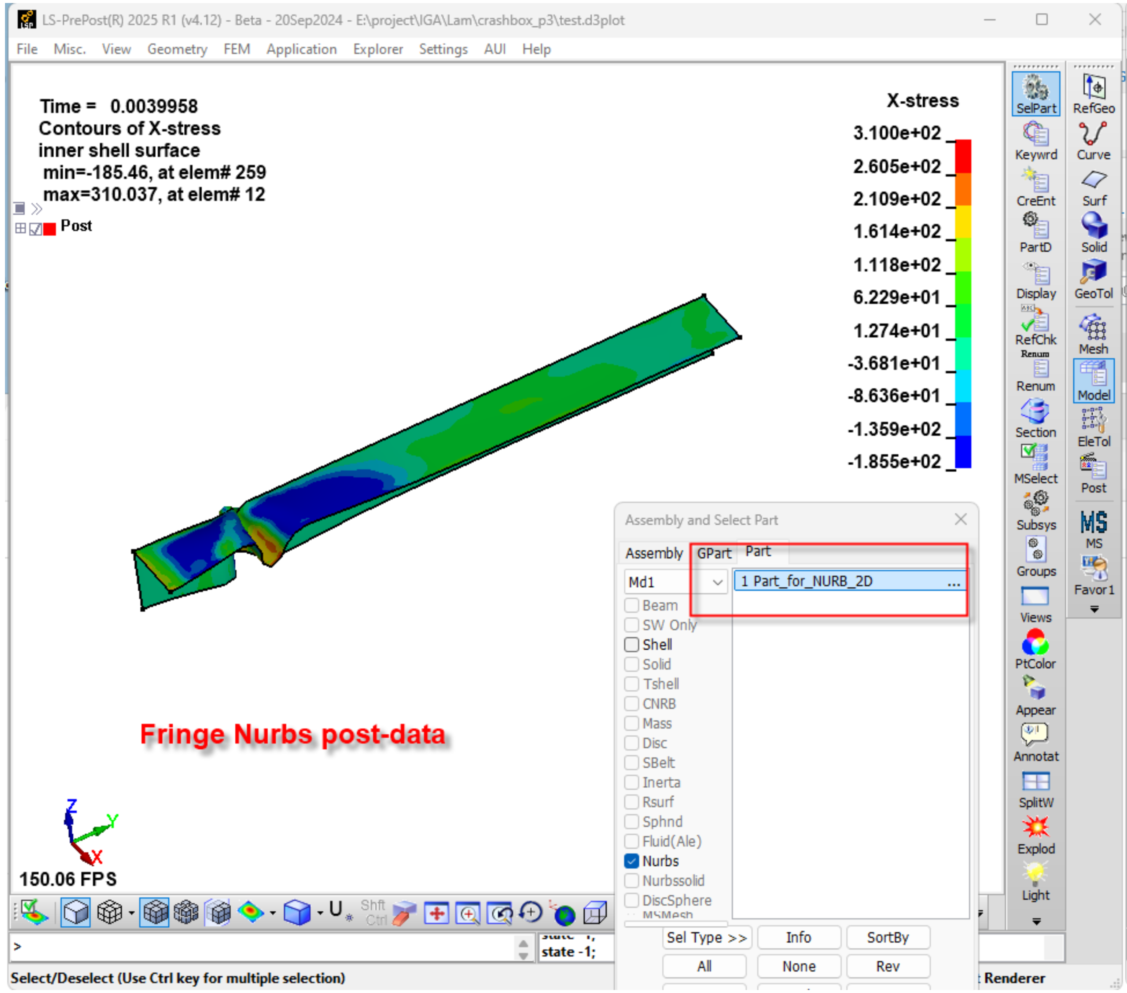
IGA shell

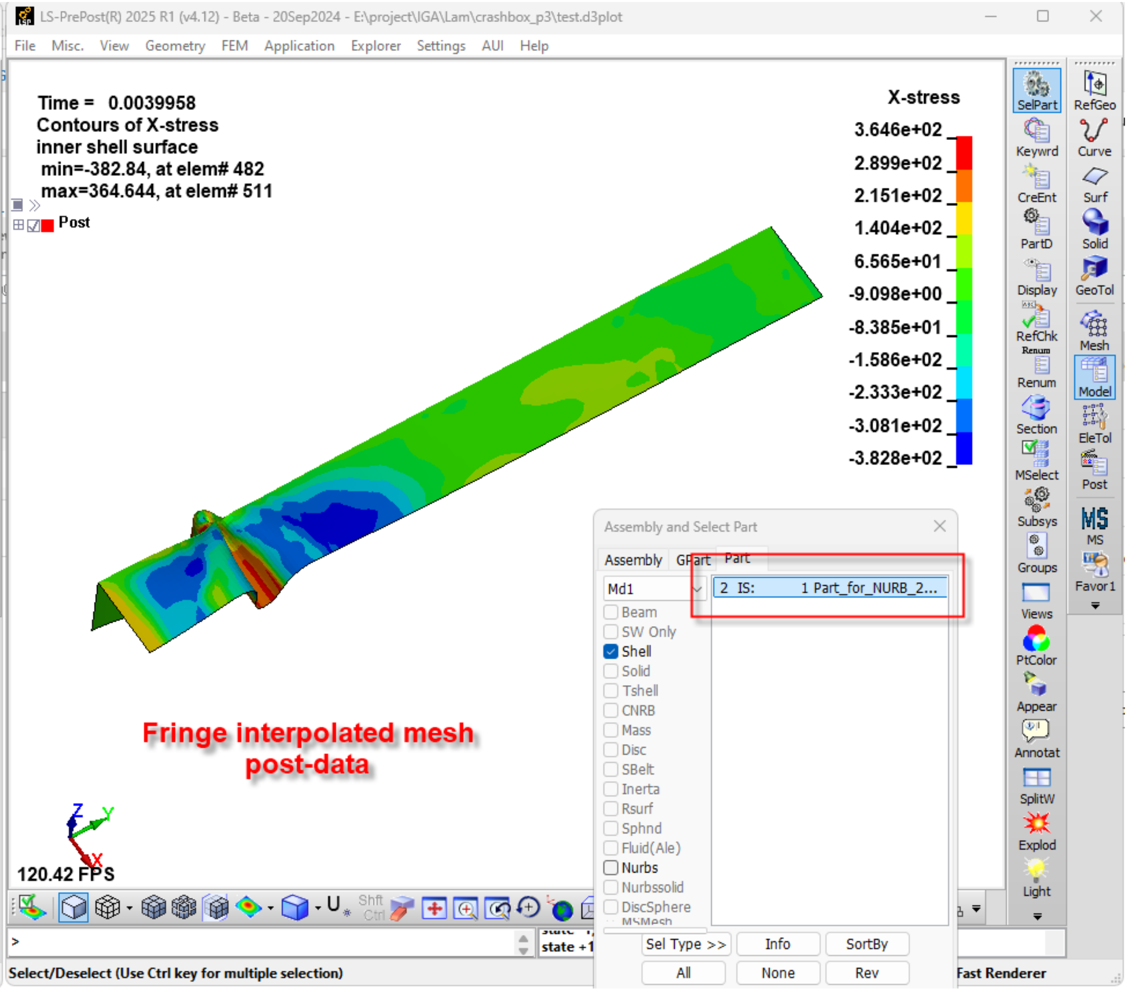


IGA solid

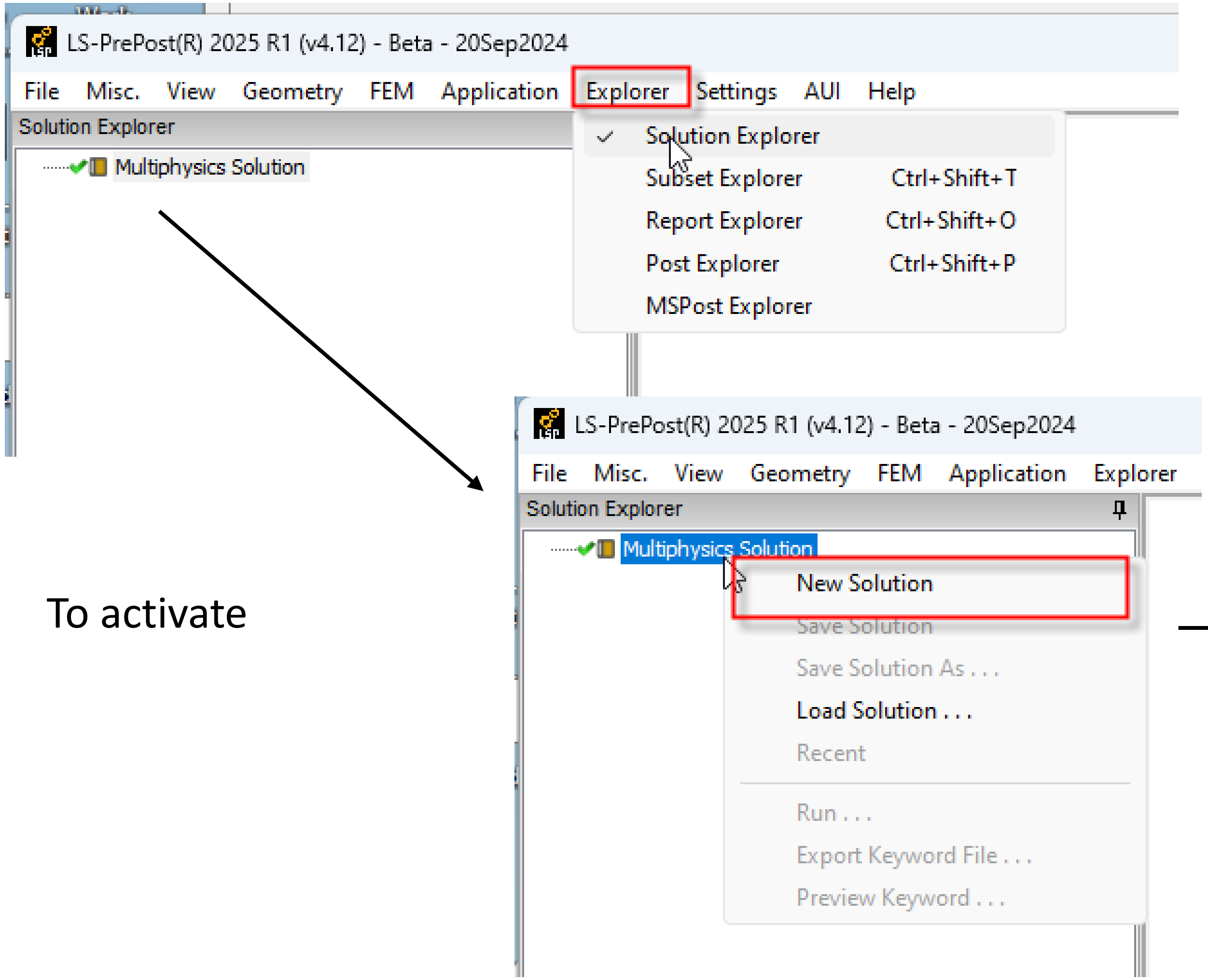
IGA Post-Processing

Fringe IGA post-processing data in Nurbs as well as interpolated mesh



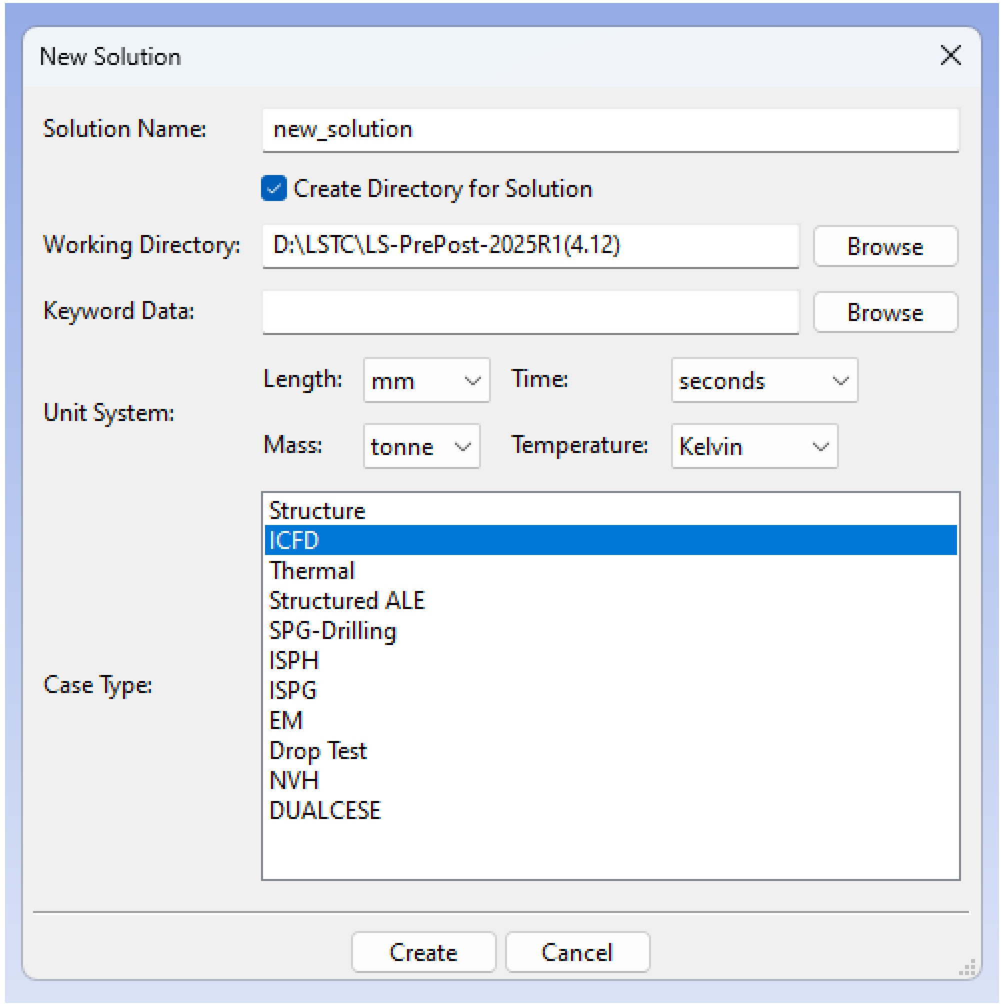


Solution Explorer – A new way to setup LS-DYNA Model

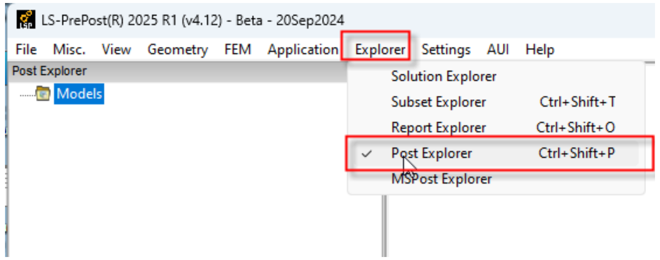


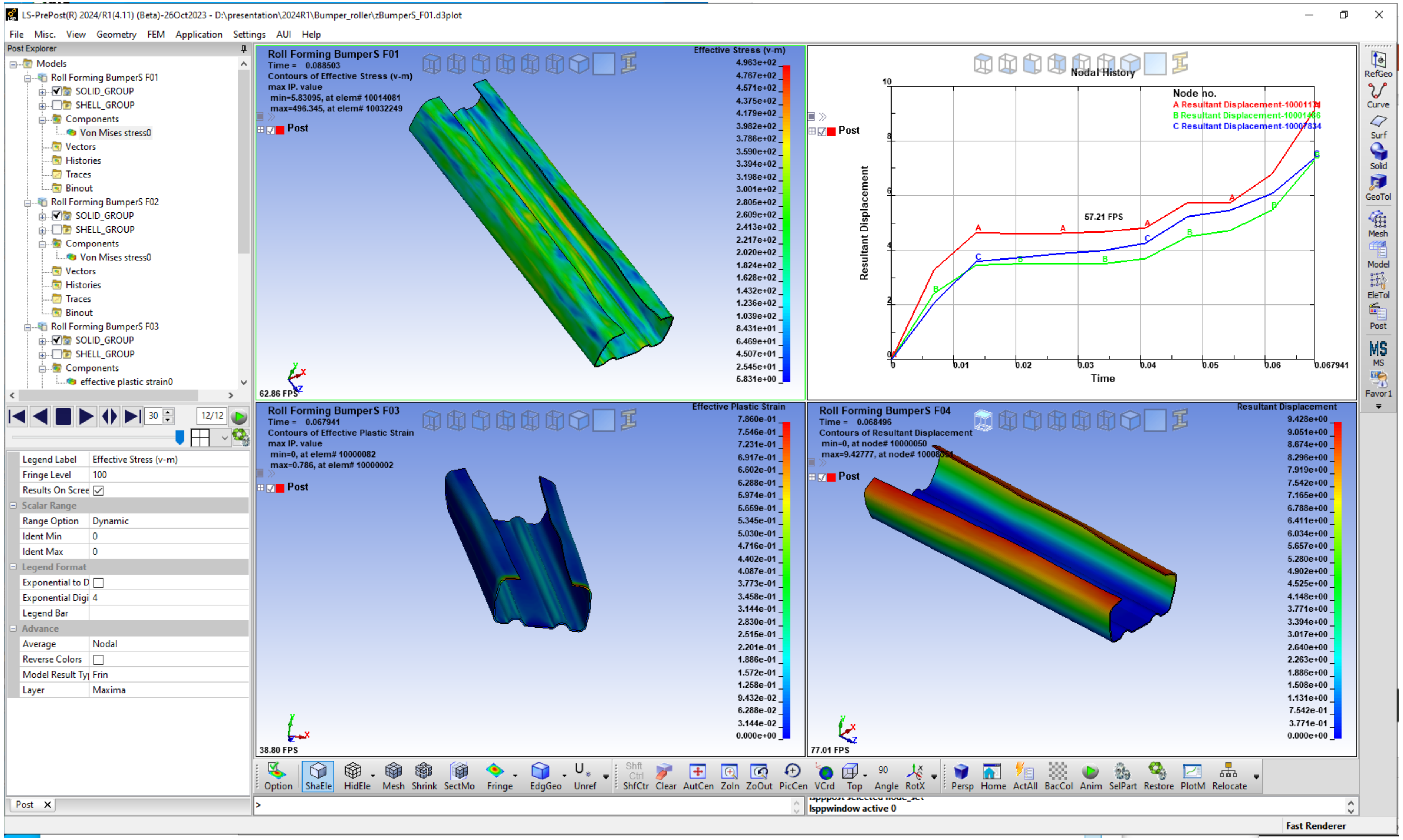
To activate

Currently supported Case Types



Post Explorer – A new way to post-process LS-DYNA results





- Multiple models can be shown on Split windows
- History data (XY plot) can also be drawn on one of the windows
- More Binout branches support

Ansys

Ansys

Thank You